RNOLOGY DEPT:

May 1946

TECHNOLOGY REVIEW

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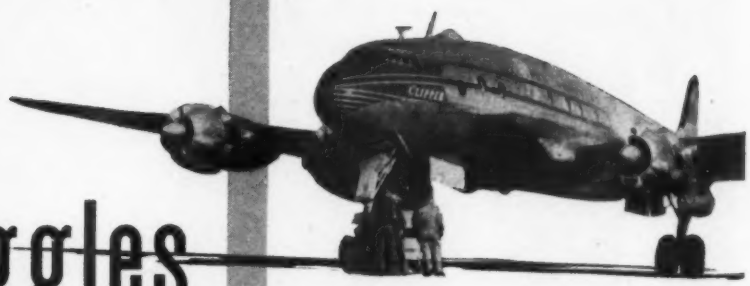
AO Safety Goggles



Help Cut Maintenance Costs of PAA Constellations

Pan American World Airways System writes: "With drastic fare reductions plus high speed operations, costly personal injuries cannot be afforded—accident prevention is a 'must.' Our pattern of Clipper maintenance has been subject to many changes, but, since AO Safety Goggles have always fitted in, it is only natural that we should reorder this equipment."

AO Safety Goggles are helping to reduce costs in hundreds of other progressive American industries. If *your* plant is not adequately equipped for cost reduction through safety, your nearest AO Safety Representative will be glad to help you work out a satisfactory program.

American Optical
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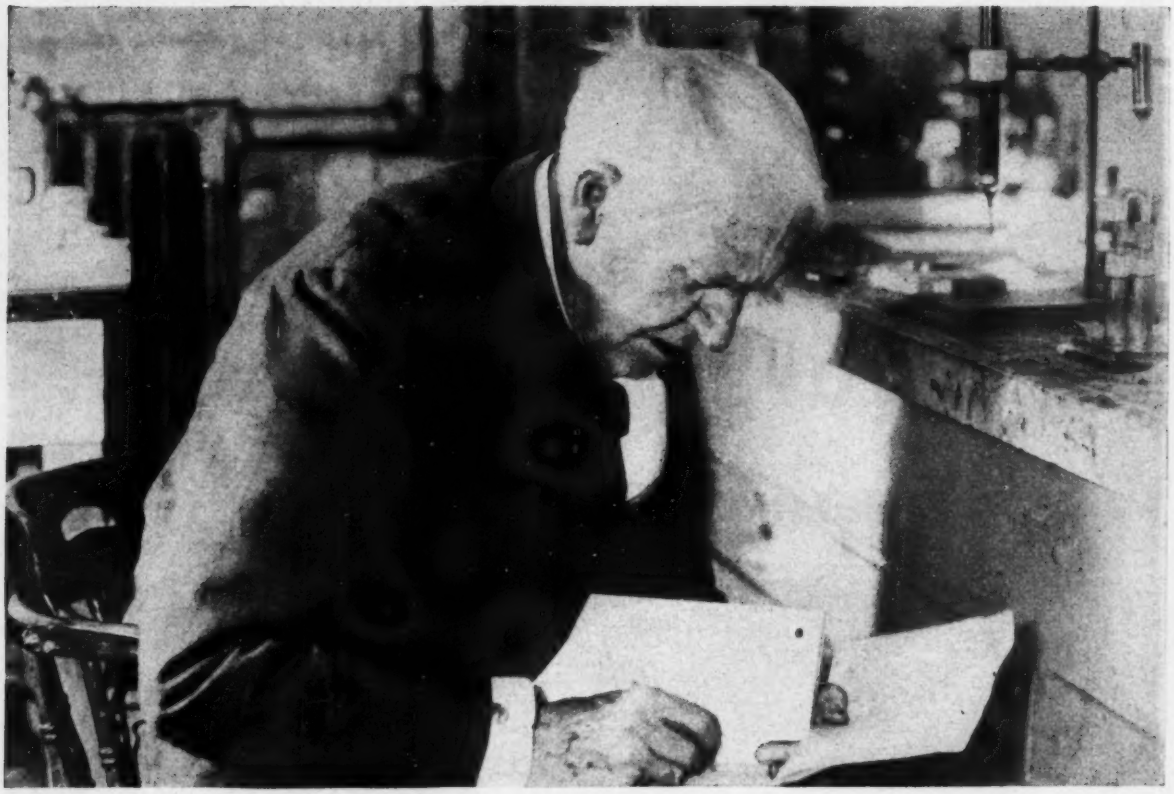
BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, May, 1946. Newsstand Edition. Vol. XLVIII, No. 7. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.



man at work...

Mathematically speaking, Mr. Average Man, by working forty hours a week for forty years, spends roughly 83,000 hours at his job during his lifetime. But Thomas A. Edison was no average man. By the time he was fourteen years of age he was doing a man's job, and doing it well. And he kept that up for seventy years. Mr. Edison devoted more than 400,000 hours to working — or five times that of Mr. Average Man — during his long and unprecedentedly fruitful life.

Make no mistake. We are not suggesting that everyone or anyone, for that matter, should work 400,000 hours. We believe the five-day, forty-hour week, generally speaking, is a good thing, although there is nothing much wrong with this country that some harder work by all of us wouldn't cure. Edison, you see, thought that security and a better life for all came from work and perspiration—not from legislation.

Incandescent and fluorescent lighting — the phonograph — motion pictures — major contributions to telephony, telegraphy, radio and electronics — these and a thousand more ideas and inventions of hard-working Mr. Edison made the world a lighter, brighter, healthier, happier place in which to live.

The wonder of Mr. Edison is that his genius and insatiable energy are still at work for you — just as much as though he were still alive. When you press a light switch, start your car, turn on your radio, play a jukebox, go to the movies, call up on the telephone, ride on a train or trolley, he is working for you — and will be for all years to come.

The infinite skill and care with which Mr. Edison endowed the fruits of his genius are qualities which, today, remain an intrinsic part of each of the products bearing his name.

Thomas A Edison

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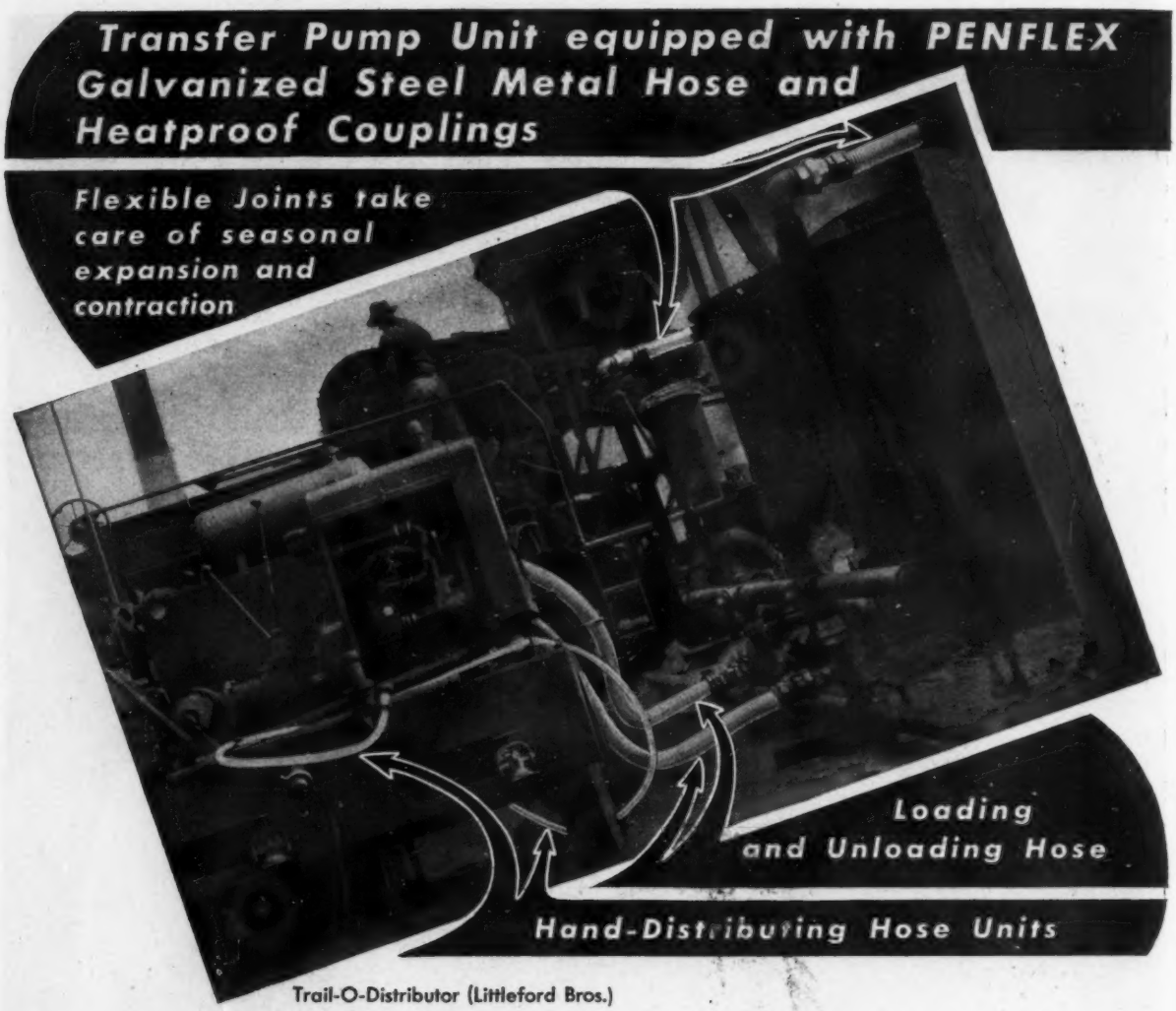
Transfer Pump Unit equipped with PENFLEX Galvanized Steel Metal Hose and Heatproof Couplings
Flexible Joints take care of seasonal expansion and contraction
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Trail-O-Distributor (Littleford Bros.)

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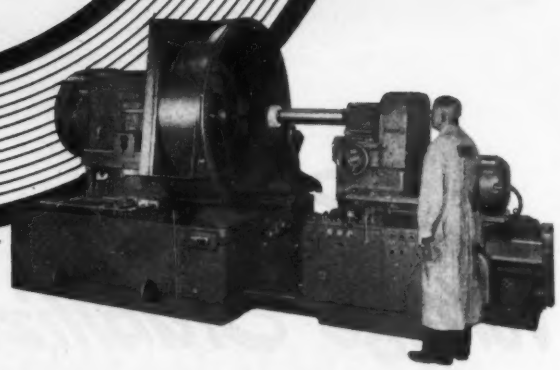

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The NEW Bryant No. 150 is a giant "internal grinder" with typical Bryant "fingertip" control. It retains the famous Bryant feature of three-point wheel slide suspension which is the basis of Bryant's reputation for high production of accurate work with fine finish.

The NEW Bryant No. 150 has a preloaded anti-friction cross slide, assuring smooth cross feed operation in spite of the size of the machine. Both hand and power cross feed are available and in addition, a hydraulic cylinder slides the wheel spindle to the rear to provide ample access for work loading or checking.

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The NEW Bryant No. 150 will handle bore or bore and face grinding in a single chucking, and bores may be either straight or tapered. Write for a copy of the new catalog sheet which gives full details, capacities and dimensions.

If your internal grinding work comes within the range of 1/16 inch diameter bore up to 60" diameter swing, it will pay you to

Send for the Man from Bryant!

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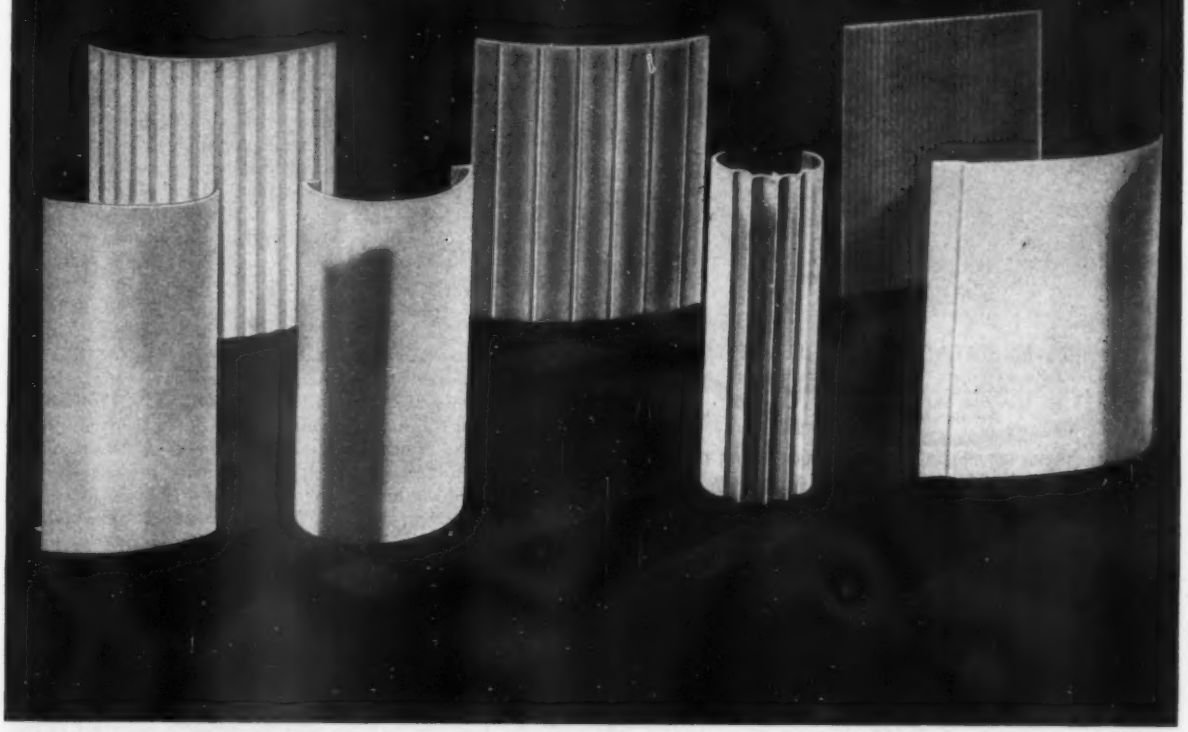

DEVELOPED FOR *Fluorescent Lighting* FIXTURES

The sections shown here illustrate Sandee progress in the development of extruded plastic sections for the rapidly expanding fluorescent lighting field. Plastics are a *natural* for this purpose. Correctly designed, and with materials properly selected they offer such impressive advantages as, 1. light weight, 2. controlled light transmission, 3. rigidity, 4. dimensional stability, 5. ease of cleaning and 6. the ability to be extruded in shapes which add to the aesthetic appearance as well as the practical efficiency of such lighting fixtures.

Our development work has been extremely educational and our technical personnel can discuss with authority your individual problems in extruded plastic sections for fluorescent lighting fixtures. This same service is also available for other sound industrial applications. Specific fields will be featured in future advertisements.

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Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.

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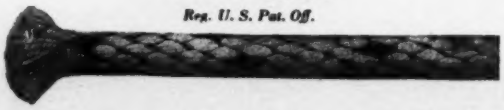


Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

THE TABULAR VIEW

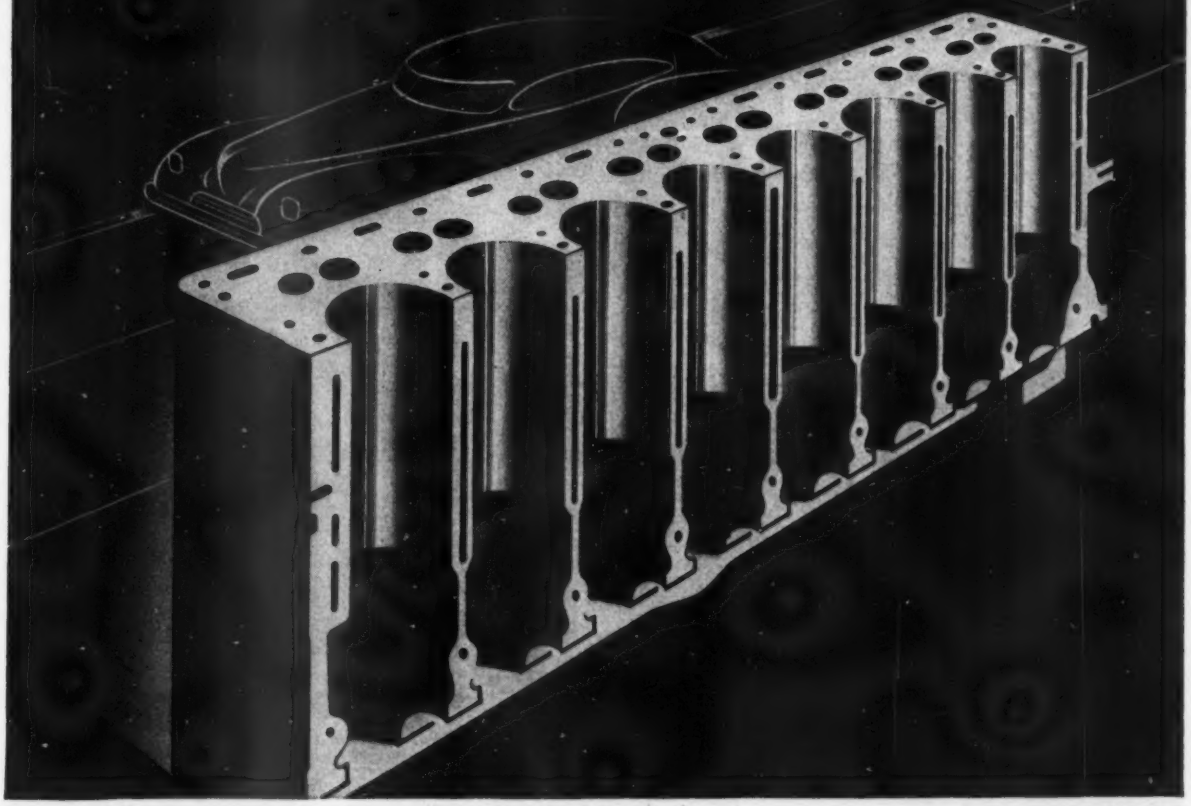
High Road to Brooklyn serves as a living monument to John August Roebling, who first invented wire rope and then advanced the design of suspension bridges further in a few decades than it had progressed in the previous millennium. In pursuit of his hobby of unearthing historical data of well-known engineering structures, E. H. CAMERON, '13, condenses for The Review material which he has gathered for a book-length manuscript on the famous Brooklyn Bridge. In the first part of this two-part article, Mr. Cameron acquaints us (page 419) with the social and engineering conditions faced by the bridge builders of the 1870's and 1880's. Head of the technical publications staff of Jackson and Moreland, Mr. Cameron has had a third of a century of engineering experience embracing the design, construction, and engineering supervision of projects in New England, the Middle West, and the Southwest.

Investing in Science for the Future calls for the creation of new institutional arrangements to provide venture capital, in the opinion of W. RUPER MACLAURIN, Professor of Economics at the Institute and son of M.I.T.'s beloved former president. Dr. Maclaurin's article (page 423) is the result of his interest in the economic aspect of science and engineering, on which problem he has been working for the past five years under a grant from the Rockefeller Foundation. A graduate of Harvard University in 1929, Professor Maclaurin was Fiske Scholar at Trinity College, Cambridge, during the following year, and as Sheldon Traveling Fellow he visited Australia in 1934 and 1935. Dr. Maclaurin joined the Institute staff as assistant professor of economics in 1936 and was advanced to associate professor in 1940 and to professor in 1942.

The Scientist's Social Responsibility is discussed (page 427) by FRANCIS BITTER, who has recently returned to the Institute as associate professor of physics after a five-year leave of absence. A graduate of Columbia University in 1924, Dr. Bitter was a National Research Fellow at the California Institute of Technology (1928–1930) and John Simon Guggenheim Fellow at the University of Cambridge (1933–1934). In 1934 he became associate professor in the Institute's Department of Mining and Metallurgy and developed a laboratory for the production of intense magnetic fields for his studies of the magnetic properties of materials. He is author of *Introduction to Ferromagnetism*. From 1940 to 1945 he was on leave of absence to the Navy Department where he worked on degaussing methods and underwater weapons. As civilian scientist and later as naval commander he set up research sections on mine warfare and naval aviation and took active part in setting up the joint Army and Navy target group to study selection of bombing targets and estimation of damage in the war against Japan. The Review is pleased to publish Dr. Bitter's article — an outgrowth of his war experience — the underlying theme of which is that the social responsibility of the scientist lies in applying the scientific method to man's social and economic problems. Comments on this Review article — and others — will be most welcome.

Recording Radar Signals which may last but a few millionths of a second has been a problem of increasing difficulty as radar signals were moved to higher and higher frequencies. HERBERT GOLDSTEIN, '43, formerly of the Institute's Radiation Laboratory and now at the Jefferson Physical Laboratory, Harvard University, describes (page 415) ways in which improvements on fluorescent screens, cathode-ray tubes, and photographic emulsions were put to use to record signals beyond the capabilities of pre-war equipment and techniques.

Molybdenum in cast iron promotes uniform hardness in varying sections.



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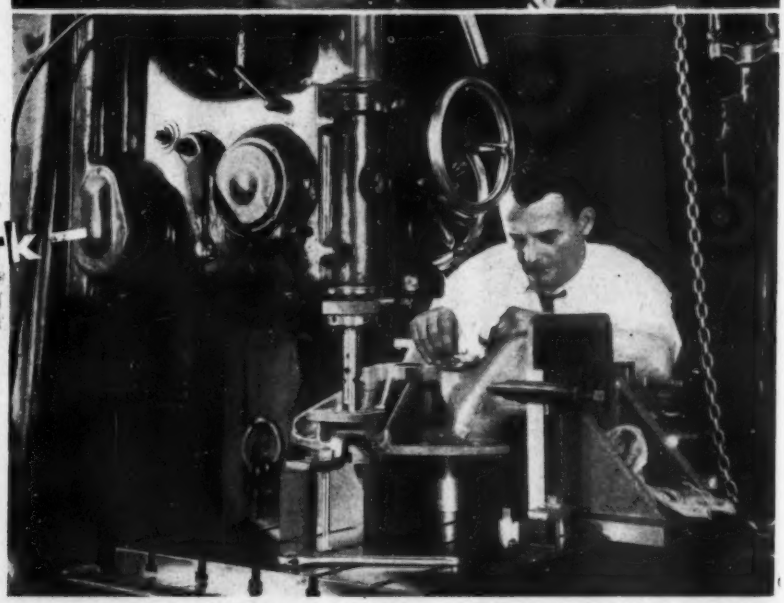
MOLY

Contract Manufacturing



—and Tool Work—

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What is more, they will *always continue* to be the main business of Taft-Peirce. So many domestic and foreign manufacturers have made it a custom to "Take It To Taft-Peirce" that the Contract Division, today, musters 1200 machine tools in a floor area of more than 300,000 square feet.

These facilities are available to you. And from them you can receive a steady flow of mechanisms, machines, fully assembled products in quantity, or a single tool or part. No job is too large or too small. And none is beyond the scope of the experience of this unique organization. For available arrangements and estimates, simply write to: *The Taft-Peirce Mfg. Co., Woonsocket, R. I.*

T-P

For Engineering, Tooling, Contract Manufacturing:

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"Where do we go from here"

Productivity Index of seven major industries in comparison with averages for "All Manufacturing" (from Bureau of Labor statistics)

	1919	1925	1931	1937	1938	1939	1940	1941	1946
All manufacturing	58.0	86.0	107.3	119.6	121.8	132.4	138.8	142.7	?
Cement	60.2	86.0	119.4	124.5	128.7	139.4	138.0	149.8	?
Chemicals	41.5	71.0	112.7	126.6	124.3	138.7	133.0	*	?
Cotton Goods	85.0	96.3	94.0	136.6	137.0	146.1	155.6	161.6	?
Automobiles	42.7	74.2	94.6	119.3	118.4	118.8	120.4	*	?
Lumber and Timber Products	95.8	92.8	109.9	100.0	106.2	121.3	129.0	133.3	?
Petroleum Refining	49.4	93.2	116.7	167.1	177.3	193.4	200.0	207.6	?
Tobacco Products	68.1	83.6	112.1	145.2	152.8	161.9	162.3	166.7	?

** Figures not available*

It is not surprising that the petroleum refining industry has an outstanding record in increasing efficiency, reducing production costs, and improving product quality, for this industry has consistently made the greatest use of all available engineering assistance.

The post-war resumption of tooth-and-nail competition means a spirited continuance of technological advancements. For the race of the future it behooves every concern, in every field, to make use of the newest methods, latest processes and most advanced engineering—particularly in the face of rising labor and other costs.

It is largely on the development of improved and more efficient processing methods and plant designs that the Badger business is founded. Badger has an impressive record of achievement in helping many chemical, petroleum and petro-chemical companies — especially in continuous-process, large-unit production, and in design for higher quality products.

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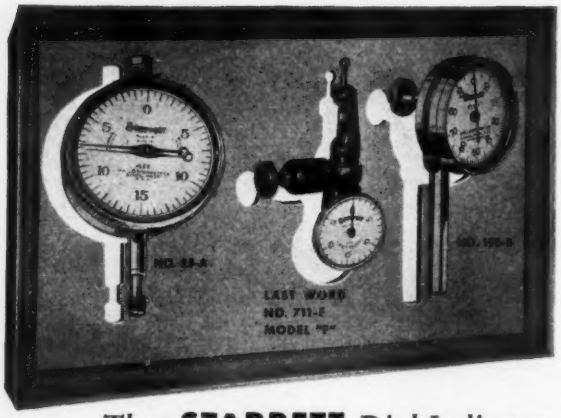
PROCESS ENGINEERS AND CONSTRUCTORS FOR THE CHEMICAL, PETROLEUM AND PETRO-CHEMICAL INDUSTRIES



These **STARRETT** *Dial Indicators Fit Into Your Production Inspection Picture*

By mounting appropriate models of these standard STARRETT Dial Indicators on tool spindles, production jigs or simple fixtures of your own design, you can "tailor to fit" countless production inspection applications. Each type has special advantages but all feature Starrett accuracy, and workmanship, clear, easy-to-read dials, maximum convenience in installation and operation. For a detailed display of the complete line of Starrett Dial Indicators, write for Dial Indicator Catalog "L".

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METAL AND WOOD CUTTING BAND SAWS • GROUND FLAT STOCK

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BATH, MAINE

MAIL RETURNS

Cover Comment

FROM RICHARD H. POUGH, '26:

James Clark of the preparation department at the American Museum of Natural History was flattered by your use of a picture of their flock of Canada geese in the dome of the Bird Hall on your March cover. I showed him the cover recently, and he was curious to know whether by any chance the photograph had been sold to you as a picture of real living geese.
New York, N. Y.

The photograph of geese was purchased for its pictorial quality alone and as possible cover material. It was evident that such a photograph could hardly have been made under natural conditions, but it was not known, until Mr. Pough's letter was received, that the photograph was made in the Bird Hall of the American Museum of Natural History. — Ed.

Selenite Sights

FROM FREDERICK A. STEBBINS:

I was interested in the discussion of the moon in the "Trend of Affairs" in the March issue. As I make a hobby of astronomy and am interested in examining the moon with an 80X refractor, I would like some further information on Gruithuisen's *Wallwerk*, not that I believe it to be genuine, but simply because such mistakes furnish something interesting to look for.

Is the *Wallwerk* the small crater now named Gruithuisen? If not, can you tell me how to locate it with reference to some of the other named craters?
Springfield, Mass.

FROM WILLY LEY:

Gruithuisen's "discovery" is not the small crater now named after him and situated at about 40 degrees east and 33 degrees north (lunar latitude and longitude). The famous *Wallwerk* is almost in the center of the visible half of the moon; the nearest named crater is *Schröter*. The *Wallwerk* borders one of the smaller rills of that section; if you begin with *Schröter* and follow the rills in the vicinity you should find it without too much trouble. On some German lunar maps it appears under the name of *Schneckenberg* (snail mountain) because it bears a faint resemblance to the shell of a snail which is partly covered with mud.

Happy hunting!
Washington, D. C.

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We have been working with this well-known chemical manufacturer for the past 18 years. The research laboratory and office building above is one of twelve buildings so far constructed under a program which is still active and continuing.

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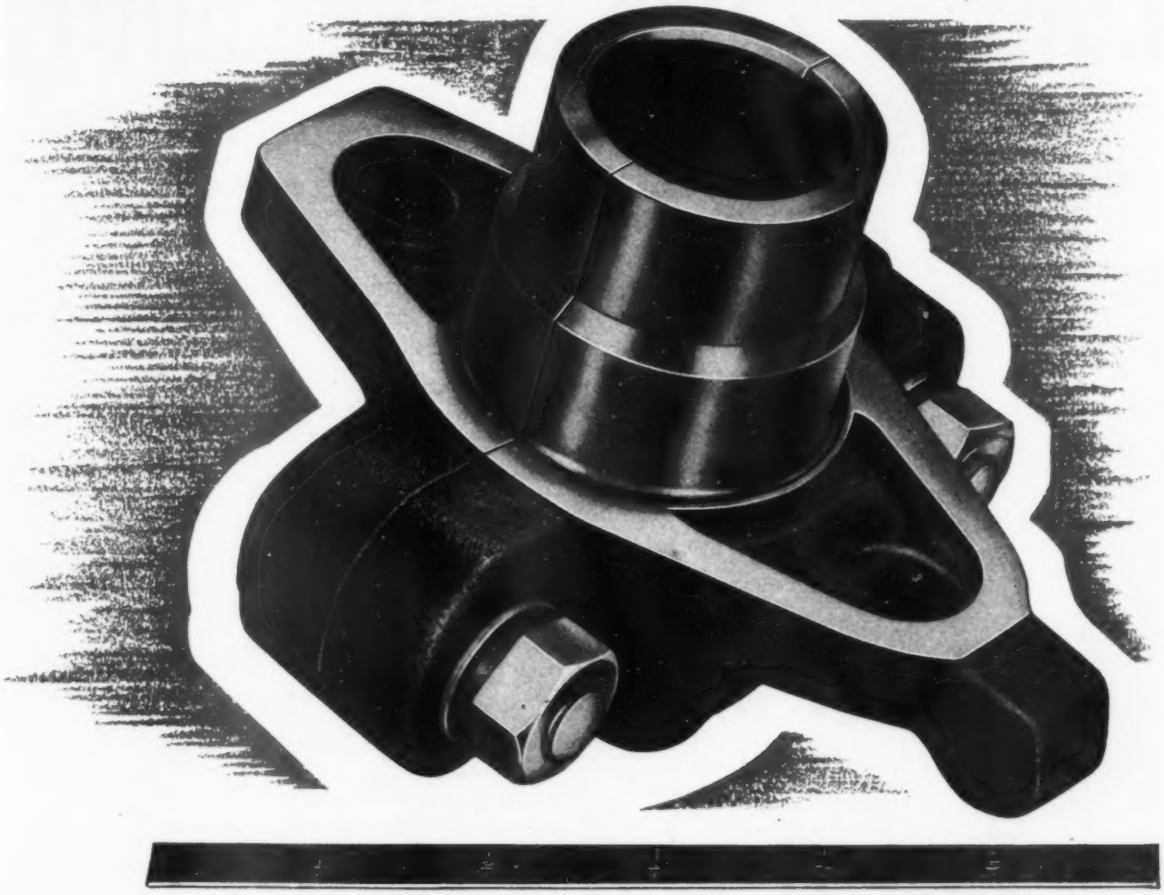
Alfred T. Glassett, '20, Vice President

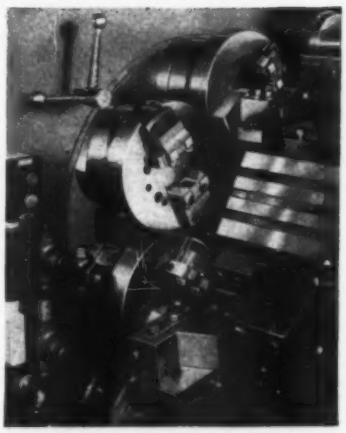
LEADERSHIP BASED ON ACCOMPLISHED FACTS...



A case of machining a complete sub-assembly

Illustrated above is a malleable iron hub used in textile machinery. The two halves bolted together as shown are loaded exactly like a single piece, and our Model 16 Six Spindle Automatic Chucking Machine performs the facing, turning, chamfering and undercutting operations with a substantial saving of time and cost.

This interesting job may well suggest important possibilities in connection with your products . . . Our engineers will gladly put their time and experience at your disposal to help you discover profit-making advancement in any machining application. Consult the New Britain sales engineer in your locality or write The New Britain Machine Company.



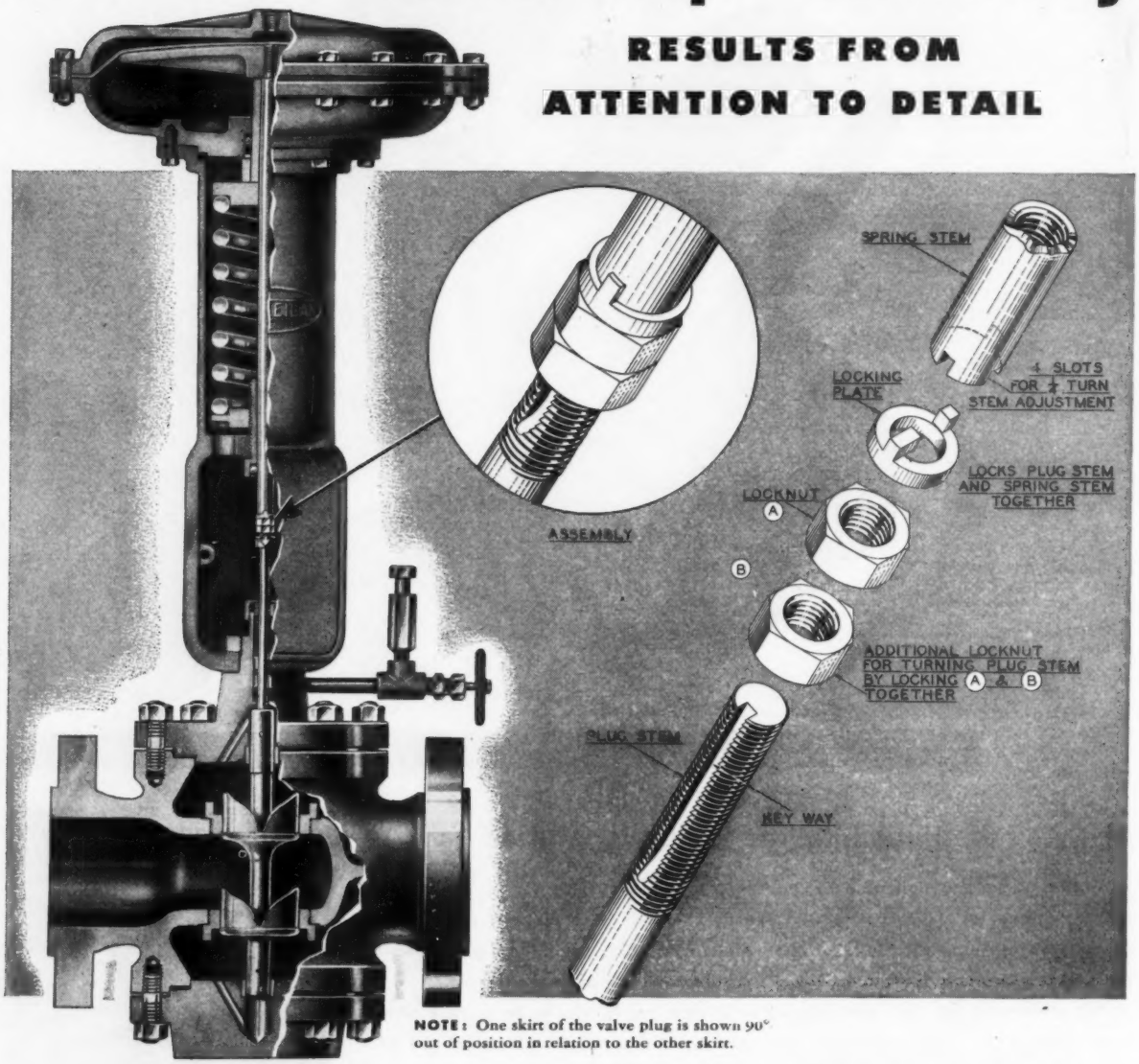
NEW BRITAIN AUTOMATICS

THE NEW BRITAIN MACHINE COMPANY
NEW BRITAIN, CONNECTICUT
NEW BRITAIN-GRIDLEY MACHINE DIVISION

M-01035

Control Valve Dependability

RESULTS FROM ATTENTION TO DETAIL



NOTE: One skirt of the valve plug is shown 90° out of position in relation to the other skirt.

New Mason-Neilan Design Provides Positive Lock Between Plug Stem and Spring Stem

Under conditions of high fluid velocities, a valve plug may tend to rotate or spin. This condition is not detrimental if the mechanical construction is sufficiently rugged to counteract the torque generated. In other words the plug, plug stem, spring stem and diaphragm button must be locked together as a unit.

In the conventional plug-spring stem assembly, the plug stem locknuts are the only non-positive fastener. Locknuts can be a source of trouble on large valves because their holding power depends on mechanical tightness.

With the Plug-Spring Stem Key Lock, standard on all valves sized 4" and above, the torsional strain is entirely removed from the locknuts and placed on the two lugs of the locking plate. This is accomplished by means of four slots milled in the end of the spring stem which receive two equally spaced lugs on the locking plate. The locknuts simply hold the locking plate in position. A keyway in the plug stem engages one lug on the locking plate and completes the lock. The four mating slots in the spring stem provide for the adjustment of the plug position by quarter turns of the plug stem.

By actual test, this new Mason-Neilan assembly withstands torsional stress to the point of stem failure. The resistance is three to four times that of tightly set locknuts in the locking direction, and many times the resistance in the counter-clockwise direction.

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In 1938 the United States produced 2,400 tons of Magnesium while Germany made six times as much. As the war progressed, the demand for aircraft and incendiary bombs increased. Magnesium had become a fighting metal.

As this country became increasingly involved in war, Magnesium became a strategic material that must be produced in quantity — at any cost. There was no time to debate processes. From 1940 to 1942 OPM and WPB built 14 plants using four basic methods never before tried in this country. In 1943, 185,000 tons of Magnesium were produced.

While three of the new processes struggled with problems of large-scale production, WPB turned to the National Academy of Science for further recommendations and was directed to the Canadian National Research Council and the Dolomite-Ferrosilicon process, then developed on a laboratory scale by Dr. Lloyd M. Pigeon.

In this process Magnesium is vaporized from briquettes at temperatures from 1100° to 1150° C. and pressures of about 10^{-2} mm. Hg. The vaporized metal is crystallized in cooled cylinders. While the process appeared to be the simplest of all the methods, it was, in practice, harassed by grave difficulties, not the least of which was the maintenance of high vacuum on an industrial scale, hitherto undreamed of.

At the request of WPB, National Research, under a DPC research contract (Plancor 708), was given the task of solving this vacuum problem, then the largest industrial project involving pressures in the micron range.

Six weeks after receiving the assignment we had a pilot plant in operation. During the following four months we designed large diffusion pumps to improve the yield and shorten the cycle, developed recording gauges for process control and evolved vacuum engineering techniques of value in the design of the larger plants.

Deliveries of equipment were made for a full-scale plant already building in Canaan, Connecticut, for the New England Lime Company. Of all the Magnesium plants begun in wartime, some completed before we were given our assignment, this was the first to be in production. Later equipment was supplied to others, including Ford at River Rouge.

It has been said of the Dolomite-Ferrosilicon process that it was "the most spectacular development of the war" and "the primary candidate for postwar scrapping". Whatever its fate, we are proud of the work that we did in making it quickly practical. This is typical of the sort of engineering that N.R.C. has to offer — the sort of service that you may expect from us when you explore the new world of high vacuum.

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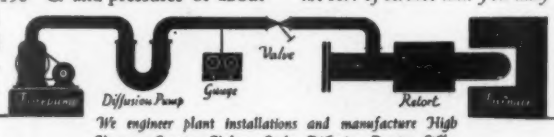

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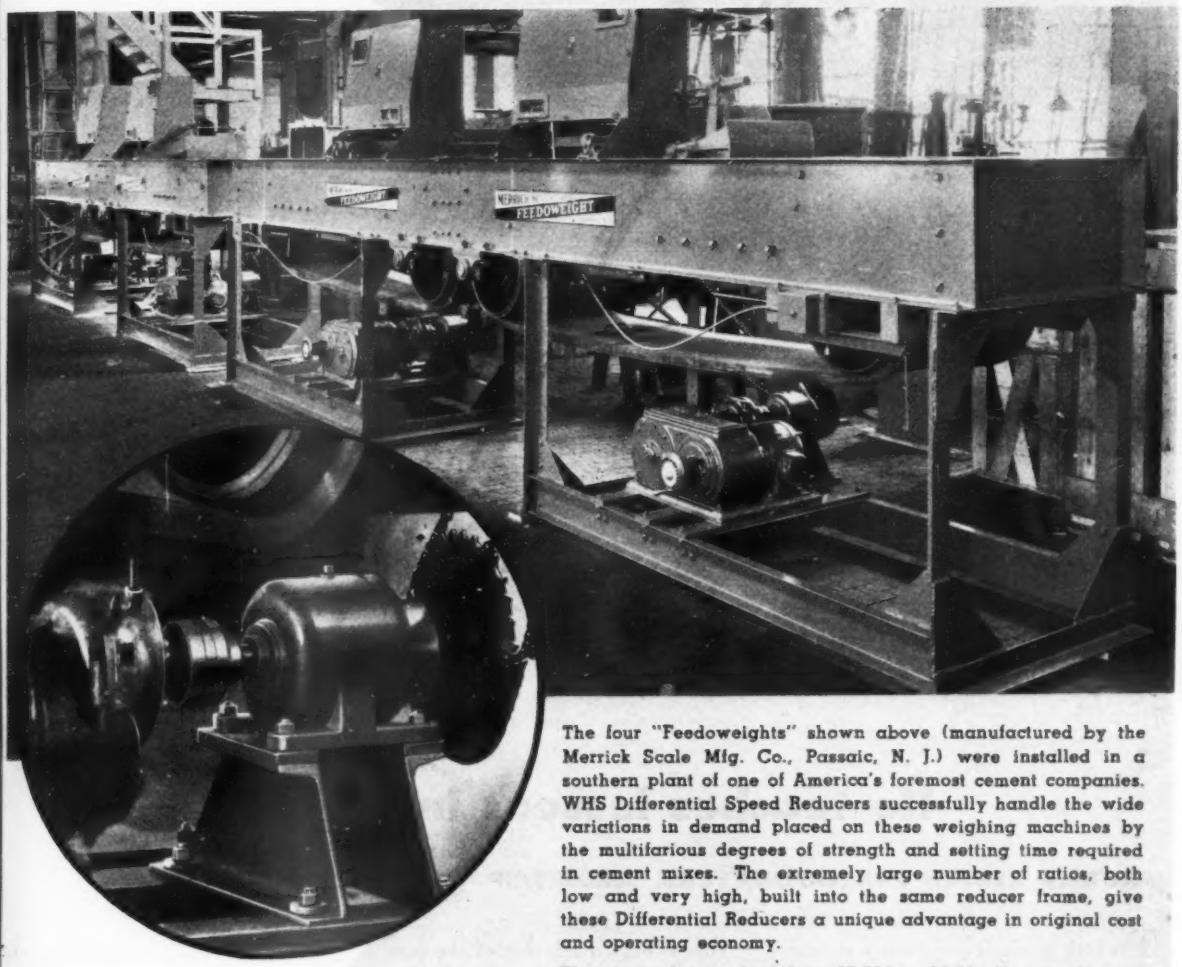

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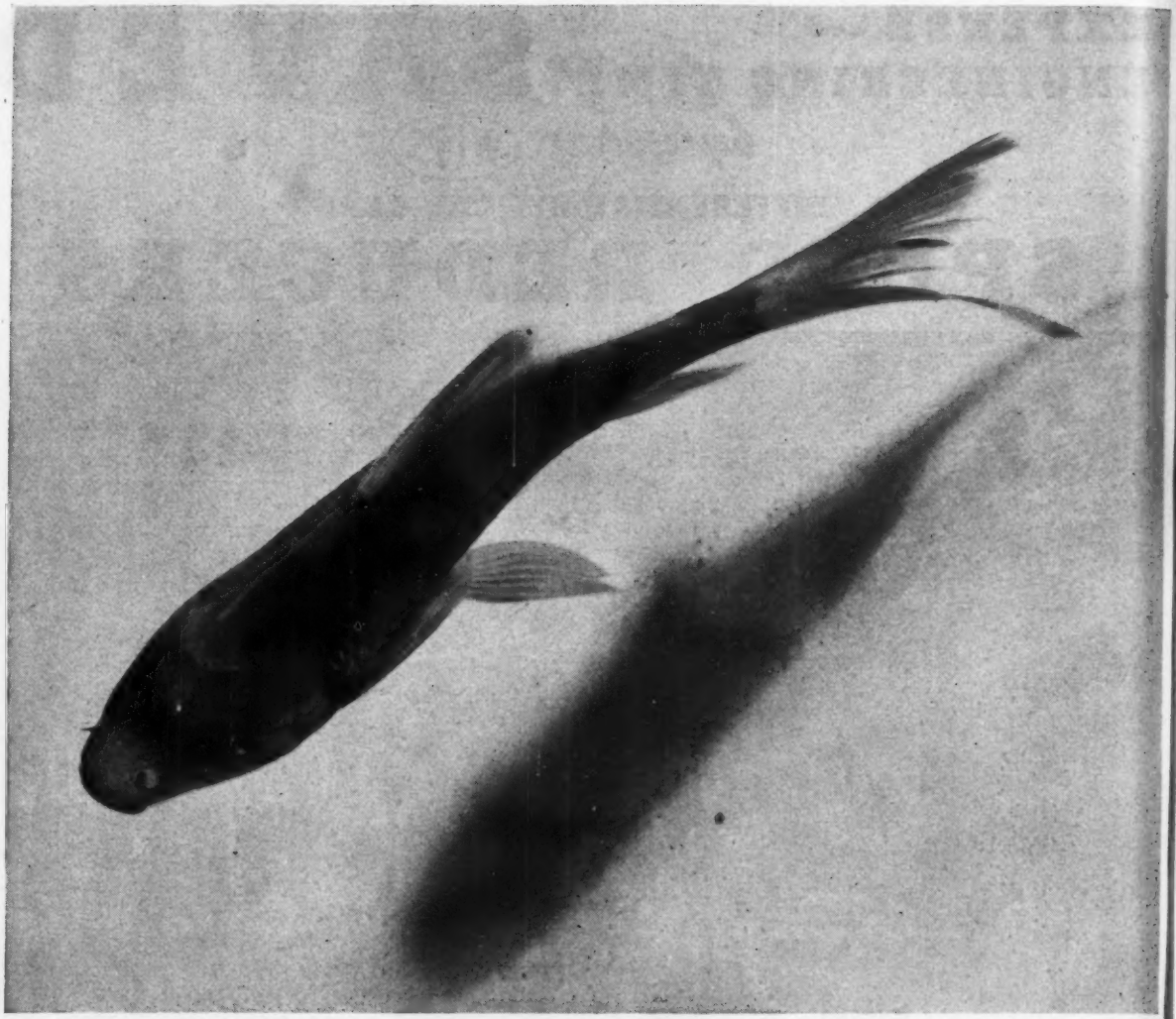

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VOLUME 48 NUMBER 7

THE TECHNOLOGY REVIEW

TITLE REGISTERED U. S. PATENT OFFICE

EDITED

AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Paul Wiswall '09

Village near Gloucester, England

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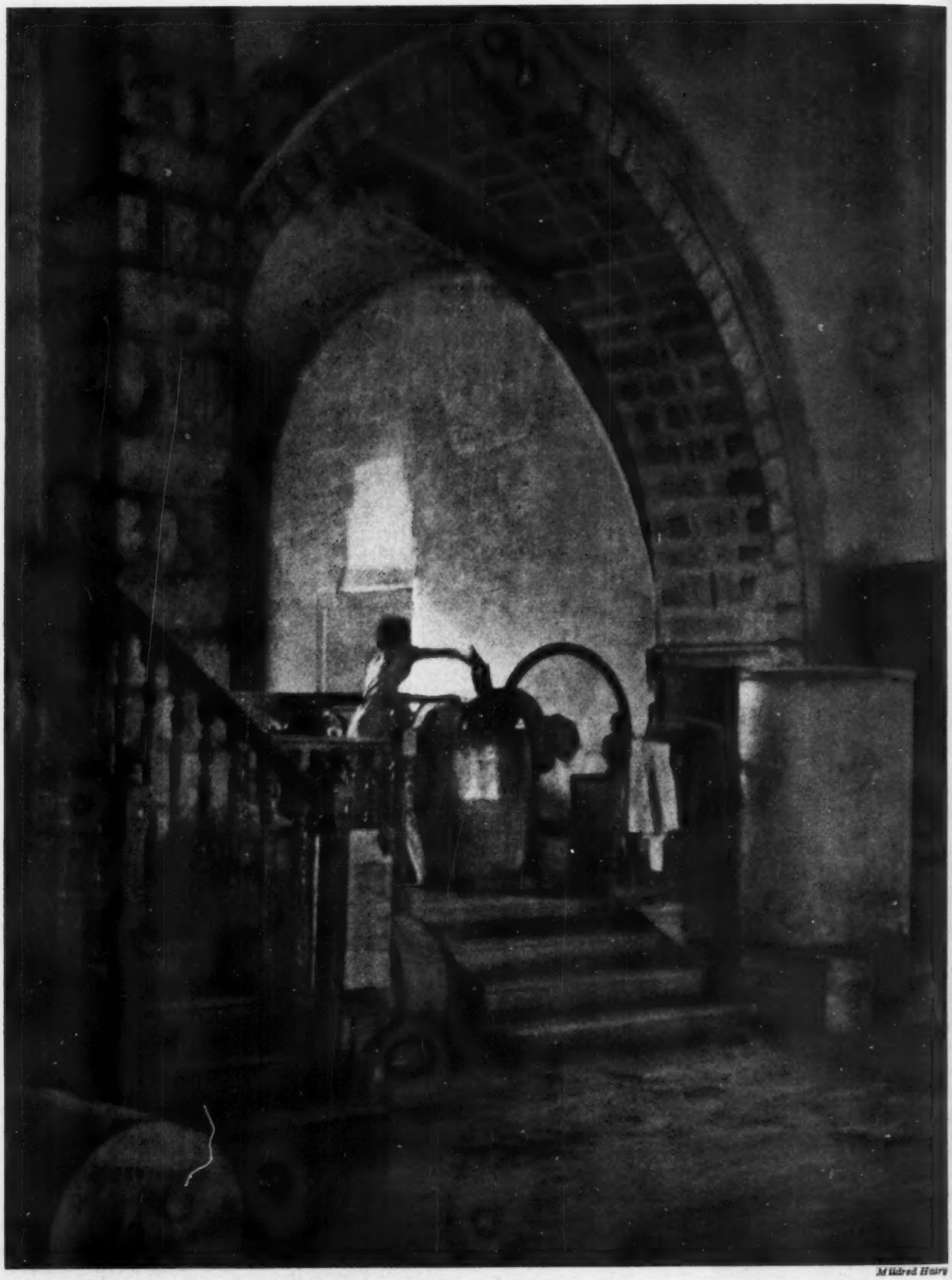


Mildred Hairs

Stirring Soap

THE
TECHNOLOGY
REVIEW

Vol. 48, No. 7 May, 1946

The Trend of Affairs

The Badly Beaten Path

AN inspection of Manhattan streets recently led the Automobile Club of New York to complain that holes and ruts had accumulated during the war years to the point where they constituted a threat not merely to the motorist's vehicle but to his life and limb as well. It is no secret that a similar picture of road deterioration can be found on rural and urban roads all over the country. Our primary highways, however, are reported to be standing up quite well.

For four years the United States has had virtually no new road construction, except for war needs, and has carried out only the most urgent of repairs on the existing structures. Considering that normally about 5 per cent of our road mileage requires replacement every year, the damage is less than might be expected. Part of the explanation lies in the fact that between 1930 and 1941 the emphasis was on modernizing and rebuilding roads rather than on extending them. The extensive state highway programs of 1936 to 1941, for example, resulted in a net decrease of 3,500 miles of primary roads. Road programs during the early Thirties, furthermore, were enormously expanded as a governmental aid to employment.

A large backlog of road and bridge construction has accumulated, nevertheless, and exceptionally heavy road programs, some of record size, are being planned by the various states. Federal aid is available at the rate of $500,000,000 a year for the next three years and for the first time includes assistance to city street programs. Unfortunately, shortages of engineers, labor, and materials, coupled with high prices, have so far acted as a heavy brake on actual work started.

Also of record size are the vacation plans of American motorists facing the first postwar year of unrestricted travel. More than $6,000,000,000, it is estimated, will be spent for this purpose in 1946. As a yardstick for this figure, it may be pointed out that prior to the war the total of tolls and gas, excise, and other taxes paid by motorists amounted to about $2,000,000,000 a year, approximately the normal yearly cost of building and maintaining the nation's 3,309,000 miles of highways.

The automobile has become a basic factor not only in this country's recreational habits (for example, the demand for and use of state and national parks is largely an outgrowth of automobile travel) but also in many more utilitarian functions. Seventy per cent of all workers get to their places of employment by car, and many important plants are not otherwise accessible. About 13,000,000 people find it practical to live in suburban areas beyond the reach of public transportation systems. Of the various trades and professions so far surveyed, the traveling salesman is the heaviest user of the automboile, traveling, on the average, about 18,800 miles a year. Doctors average almost 13,000 miles a year, and the over-all average for all users of cars is about 8,100 miles a year.

It is well-nigh time that we gave thought to replenishing the badly beaten path as merrily we roll along.

Recording Radar Signals

By Herbert Goldstein

ELECTRICAL engineers seeking to protect electric power lines against lightning strokes and other breakdown discharges have long had to study electrical transients, occurring in such discharges, which last only fractions of a microsecond. In a form far less perfect than the now familiar tube of television and radar, the cathode-ray oscillograph has been used in such studies for more than a generation. Because the time interval under consideration is so short, the electron beam moves rapidly across the fluorescent screen, and it becomes difficult to photograph the trace produced.

Two steps were early taken to increase the maximum beam speed which could be recorded. First, the photographic film was inserted inside the oscillograph so that

the electrons struck the film directly without an intervening fluorescent screen and camera. Of course, complicated vacuum pumps and locks then became necessary. Second, the electron beam was accelerated by very large potentials — up to 90,000 volts — so that the electrons struck the film with great energy and produced an image even though they moved across the plate rapidly. Beam speeds as fast as 200 feet in one microsecond, one-fifth the speed of light, were recorded in this fashion!

In a high-voltage oscillograph a correspondingly high signal voltage is needed to deflect the beam. This requirement is of little consequence, of course, to the engineer working with high-tension lines, but it rules out the use of such oscillographs by the radio engineer who has only small voltage available. Until recently, however, he had little need for very high-speed recording. When Sir Watson Watt, the "father" of radar, began to study the applications of the low-voltage cathode-ray tube to radio engineering, he reported that the maximum beam speed which he could record was less than one inch per microsecond. At the time, that was quite sufficient.

The situation changed with the intensive development of radar. Not only did the radio frequencies involved mount to astronomical figures, but one became concerned with pulses of energy lasting only a few microseconds or less. Thus a number of high-speed recording problems arose in connection with the work at the Radiation Laboratory. One, the recording of individual cycles of a radio wave having 3×10^9 oscillations per second was solved by a modified form of the high-voltage cathode-ray tube.[1] In another problem it was desired to record the individual radar echoes from each pulse transmitted by the system.[2] The maximum writing speed needed was not as great, only a few feet per microsecond, but the complications of a vacuum system were to be avoided, and, in addition, the deflecting voltages were necessarily feeble. By combining a number of developments of the immediate pre-war and war periods, it was found possible to record conveniently speeds of a few feet per microsecond using ordinary commercial sealed-off tubes. Photographic films are now available that are several times more sensitive than Super XX. It was found that a fluorescent screen developed for a specialized radar tube gave an image 10 times more brilliant than that previously obtained. Finally, the beam was accelerated by a potential of several thousand volts *after* deflection by the signal voltage, so that relatively low voltages may still be used for deflection while reaping the advantages of a fast electron beam.

The Du Mont Laboratories have recently extended this basic idea, which is several years old, in some special tubes in which the beam is accelerated by 33,000 volts, with deflection sensitivities almost as good as with ordinary tubes. Such tubes can record speeds of many feet per microsecond and bid fair to replace the cumbersome continuously evacuated high-voltage tube.

One problem new to high-speed recording was encountered in the radar work. A radar set will send out a pulse and receive echoes as many as 4,000 times a second. Thus it was necessary not only to photograph the rapidly moving electron beam but also to repeat the photography 4,000 times in one second. This frame frequency is far above that of ordinary movie cameras (about 16 frames a second), so that it was necessary to modify special high-speed cameras for the purpose. At somewhat lower speeds cameras of the home movie type were used successfully in a much modified form. A phototube, lamp, and slotted disk mounted on the drive motor were used in one of them to "fire" the radar set synchronously with the motion of the film. The resultant reel could then be projected as a movie, and the fluctuations of radar echoes thus could be slowed down to one-twentieth of their normal value for convenient study.

[1] See "Expanded Horizons," by L. A. du Bridge and L. N. Ridenour in The Review for November, 1945.

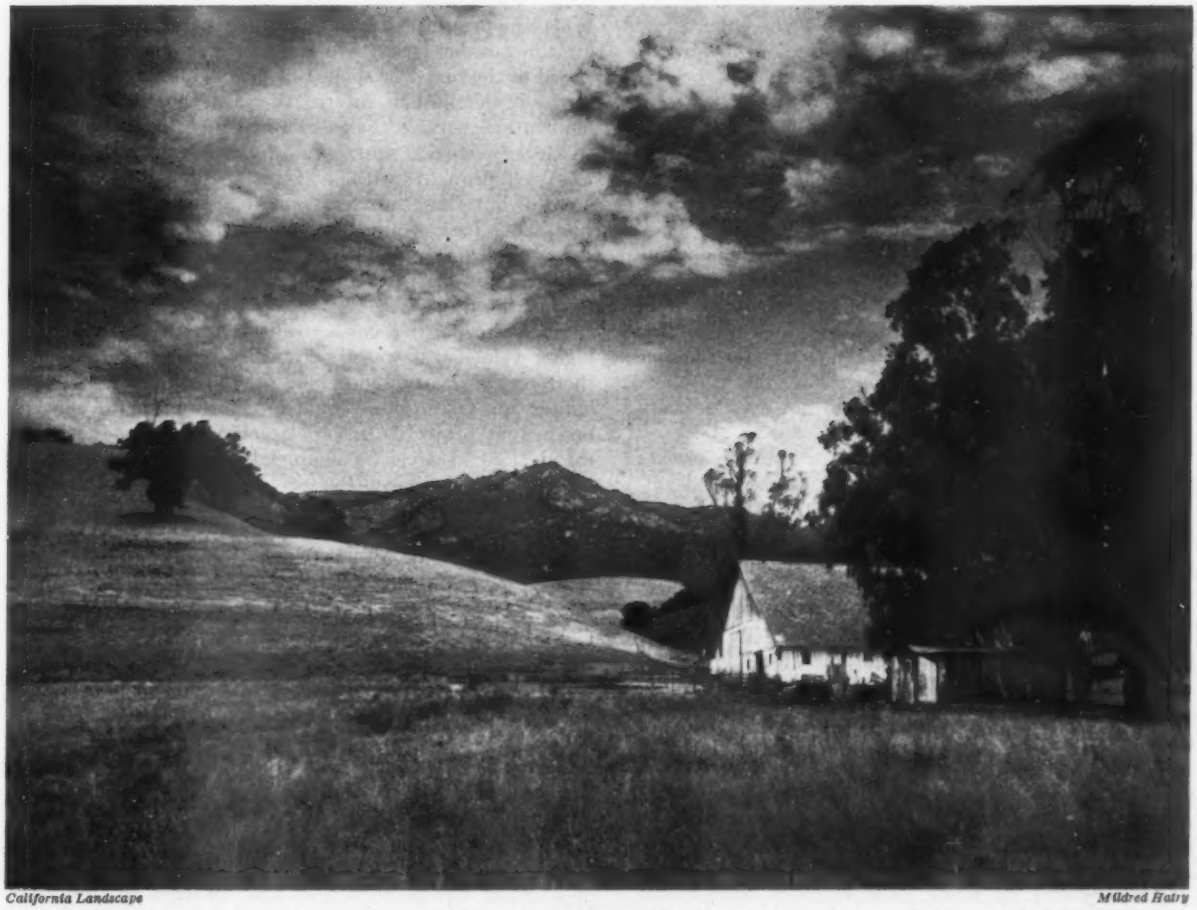
[2] See "High Speed Photography of the Cathode-Ray Tube," by H. Goldstein and Paul D. Bales, *The Review of Scientific Instruments*, March, 1946, p. 89.

Pellagra Paradox

AT the time of Christopher Columbus, peoples dwelling in the central section of the Old World depended upon wheat as their staple cereal food, and the inhabitants of the southeastern part of that hemisphere were similarly dependent upon rice. Before the discovery of America, corn (maize) was the only cereal crop grown in the Western Hemisphere and was an important part of the diet of many American Indian tribes. Today, as of old, wheat retains its predominance in Europe, where vast quantities of this grain are eaten as bread or as alimentary pastes. Likewise, the Orient now, as at the end of the Fifteenth Century, depends upon rice for its staple food. But when white men came to the New World they brought with them the wheat of Europe; this grain quickly displaced the native maize, with the result that now over five times as much wheat as corn is consumed in the United States. But corn consumption here is largely localized in the deep South, where much hominy grits and corn-meal hot breads are eaten. As a result, the per capita consumption of corn in the southern United States is high.

The rice-eating Orient suffers from the scourge of beriberi; pellagra is correspondingly common in the corn-eating southern United States. The United States Public Health Service early concerned itself with the southern pellagra problem and was responsible for Goldberger's classic researches, which in 1920 showed pellagra to be a dietary deficiency disease that may be prevented or cured by liberal consumption of certain protective foods. Search for the specific dietary factor the lack of which causes pellagra was thereupon initiated. These studi culminated in 1937 with the discovery that insufficie intake of the B vitamin niacin produces the most chara teristic symptoms of pellagra.

Niacin has a more colorful background than has any other vitamin, first of all because niacin's history exactly reverses that of the other vitamins. The other vitamins were initially recognized through their nutritional effects; then vast quantities of some food identified as a rich source of the particular nutritional factor were processed to extract minute amounts of the vitamin. Finally this isolated natural vitamin was studied by organic chemists for the purpose of determining its chemical structure and in order to make possible the final step, chemical synthesis of the pure vitamin. In contrast, niacin, under its original name, "nicotinic acid," was isolated from the tobacco plant and was identified, catalogued as an organic compound, and successfully synthesized long before vitamins were known. Then, as we have seen, niacin's vitamin character was not recognized until 10



California Landscape — *Mildred Hairy*

Reminding us of the need for supplying food for a war ravished world is this exhibition print recently shown at the Institute.

years ago. This strange history of niacin underlies the dramatic fact that all the time Goldberger was struggling to solve the riddle of pellagra, at times with little promise of success, a bottle of niacin stood upon the shelves of his laboratory.

The other unique episode in the story of niacin is this vitamin's change of name. This change grew out of the choice of niacin, along with its fellow B vitamins, thiamine and riboflavin, for addition to flour and bread in the most significant nutritional reform of our times, the food enrichment program. When the time came for declaration of nicotinic acid on the labels of enriched bread and flour, it was realized that to the layman nicotinic acid, as an ingredient of foods, suffered from the double stigma of association with tobacco and acidity. Hence, by agreement of scientific and governmental authorities, nicotinic acid was rechristened "niacin."

Although the dietary deficiency nature of pellagra was thoroughly established a quarter of a century ago, and although a specific preventive factor was later identified in niacin, one aspect of the pellagra problem has challenged explanation. This paradox of pellagra is: Why is pellagra found mainly among populations consuming large amounts of corn? Niacin shortage of high corn diets is not the whole answer, for niacin intake of certain of the rice-consuming peoples of India has been shown to be below that of pellagrins in this country, yet pellagra is rare in India. Likewise it was demonstrated in 1942 that the average niacin intake of residents of Wayne County, N. C., a section where corn consumption is low and pellagra is unknown, was exactly the same as the calculated niacin level of the high corn diets consumed by the subjects in Goldberger's classic studies, yet Goldberger's subjects were pellagrins.

From these observations it follows that corn must have some positive pellagra-generating effect, aside from its deficiency in niacin. The existence of such a relationship has, in fact, been proven by experiments with laboratory animals. Then certain of these experiments were extended to yield at least a partial answer to the paradox, for they showed that corn has a specific anti-niacin effect and that this effect may be offset by the liberal addition to the diet of casein, a protein of milk. Later the protective value of casein in high corn diets was narrowed down to one of this protein's component amino acids, tryptophan. Since tryptophan is poorly supplied by corn, it now becomes clear that high corn diets may produce pellagra through a dual deficiency of the vitamin niacin and of the amino acid tryptophan. The mechanism of the relationship has not been explained experimentally, although a published theory postulates that ample dietary tryptophan may support growth, in the intestinal tract, of micro-organisms capable of synthesizing niacin, thus compensating for a shortage of niacin in the dietary intake.

These observations explain satisfactorily the rarity of pellagra among the rice-eating millions of the Orient, for, although rice contains even less niacin than does corn, rice contains considerably more tryptophan.

Recoilless Guns

EVER since the invention of firearms, some 600 years ago, it had been proverbial that a gun had three characteristics which were completely unwanted: They belched huge clouds of powder smoke into the landscape, they made an unholy (and betraying) noise, and they kicked back. Although all three of these features were unwanted, their inevitability was so much taken for granted that anybody who dared even to wonder whether powder might not be made smokeless, or guns noiseless, was considered a hopeless crank. And not even a crank would think of making guns recoilless.

By now we take smokeless powder for granted, smokeless at least by comparison with the smokescreen developed by batteries and battalions firing the old-fashioned black powder; and although noise reduction is actually very difficult and has not been carried very far, we have had recoilless guns for quite some time.

The first attempt to build a recoilless gun is exemplified by the Davis nonrecoil gun of 1917, originally planned as an airplane cannon. The Davis nonrecoil gun took advantage of Sir Isaac Newton's third law of motion, stating that reaction is equal (in power) but opposite (in direction) to action, or the actions of two bodies are equal (in power) but point in opposite directions. Applied to a firing gun this law made it clear that the recoil of the gun was simply the reaction of the whole piece against the firing of the projectile.

At first, that reaction of the whole piece had been restrained merely by ropes; then designers had created special recoil-absorbing mechanisms, consisting of cylinders and pistons moving against springs or liquids, or both. The Davis gun was the result of the thought of providing a special "recoil mass" which would take up the reaction for the gun. Consequently, the cartridge was made to consist of three instead of two parts: the projectile proper, the propelling charge, and the recoil-mass, a cardboard container filled with buckshot. This cartridge was inserted in the middle of a long barrel of 2.25-inch caliber.

The front section of this barrel was rifled, the rear section was smoothbore. When the projectile was fired, the two masses, projectile in front and buckshot container in back, produced two mutually neutralizing reactions in opposite directions, so that the gun itself did not move at all. The cardboard container broke up when fired, so that the buckshot, finding a much higher aggregate air resistance than the single projectile, did not have a long range. The danger area behind the original nonrecoil gun was only about 200 yards long, and it would have been easy to provide a backstop for the buckshot if this gun had been used on the ground.

But after World War I another solution of the recoil problem, developed originally by the engineers of Schneider-Creusot, gained greater currency at first. The Creusot engineers had utilized the fact that the powder gases which leave the muzzle of a gun after the projectile has left it are from two to three times as fast as the projectile. The mechanism utilizing this feature consisted essentially of a "false muzzle" attached to the front end of the gun. When the projectile left the real muzzle it opened the way for the powder gases, which had the tendency to race ahead of the bullet or shell. But meanwhile the front end of the projectile had entered the false muzzle, sealing it momentarily so that the gases were caught in the enclosed space between real muzzle and false muzzle. That space was well provided with vents in the shape of exhaust nozzles, but these nozzles pointed in the opposite direction. Therefore, while the gun barrel was just about to slide backwards under the recoil from the projectile, it was arrested by the recoil of the gases which opposed that of the projectile.

Since the powder gases, while lesser in mass, had a higher velocity, it was theoretically possible to balance the forces perfectly, by making the opposing recoil of the lighter and faster gases equal to the recoil of the slower but heavier projectile. In practice, however, this theoretical ideal could never be completely attained; the muzzle brake as a rule reduced the recoil appreciably so that the remainder could be taken up by a much lighter and smaller recoil mechanism.

But even though ordnance departments of all countries showed a pronounced infatuation for the muzzle brake, the other idea was not completely neglected. After the victory in North Africa a German recoilless howitzer of the Davis nonrecoil gun type was found; it had a caliber of 105 millimeters (about four inches) and was backed by a sand wall which was to catch the recoil-absorbing buckshot.

Naturally it was also possible to do without the buckshot and create a counter recoil merely by permitting part of the powder gases to escape in the rear and by utilizing it properly. It has now been revealed that our Ordnance Department has spent a considerable amount of work on the perfection of that thought so that the American forces are now in possession of several types of recoilless guns of amazing characteristics.

One of them is a 57-millimeter cannon, firing 2¼-pound artillery projectiles to a maximum range of two and a half miles. An ordinary 57-millimeter cannon would weigh around 3,000 pounds; the recoilless type weighs 45 pounds, and it can be fired from the shoulder like a rifle, with which it compares in accuracy.

A 75-millimeter recoilless gun weighs about 110 pounds (even the little 75-millimeter pack howitzer, the lightest artillery piece in existence so far, weighed 14 times as much) and can be fired from a tripod mount, which is not larger or heavier than the tripod mount ordinarily used for machine guns.

Such recoilless artillery will provide the infantry regiment of today with more fire power than the artillery regiment of yesterday could muster. Needless to say, such portable recoilless artillery is again much superior to the portable rocket launchers which substituted for the then nonexistent portable artillery. The projectile from a portable gun is far superior not only in accuracy to any rocket shell but also in range and in penetration. And although the firing tubes of recoilless artillery are necessarily heavier than the launching tubes of rocket projectors of the same caliber, the weight of a round of ammunition is apt to be less, since the powder charge required to launch a projectile from a tube is much lighter than the powder charge of a rocket for a projectile of the same weight.

High Road to Brooklyn

The Half Century of Engineering Progress Since Its Completion Serves Merely to Heighten the Respect with Which We Regard Those Who Planned and Constructed the Brooklyn Bridge

By E. H. Cameron

I

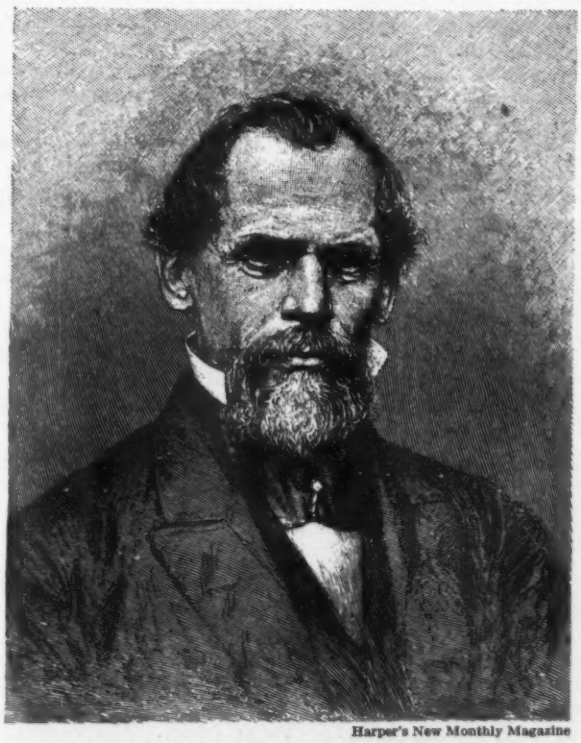
THE typical bridge engineer is an uneasy fellow who is never content with present methods. He strives constantly to advance the outposts that mark the frontier of engineering design — assumptions that are more truly rational as to loads and their distribution, more precise methods of stress analysis that are not too cumbersome mathematically, and, above all, the adoption of new materials which promise savings in both dollars and weight. He is happiest when his courageous advances allow him to build a structure of hitherto unheard-of size. From this fine quality of discontent with the old, coupled with an eagerness to build something bigger still, arises the high respect, bordering on reverence, in which modern bridge engineers hold the conceiver of the Brooklyn Bridge, John August Roebling, and his associates who built this inspiring structure after his untimely death. For these men created a structure wherein pioneer materials were used to construct members of such unusual dimensions that the Bridge was called the "eighth wonder of the world" when completed in 1883, after 13 years of arduous construction activity.

Many rule-of-thumb methods were used in computing the sizes of cables, anchorages, and other bridge members. At the same time, common sense was so skillfully applied to the meager theories of structural design of the period that modern designers of suspension bridges concur in their respect for the ability exhibited by John A. Roebling in his attack on the basic problems of a bridge of this type.

The Brooklyn Bridge was built the hard way. Large quantities of candles were used to light its caissons fathoms beneath the surface of the East River.[1] There were no electric motors for hoists or cable-spinning apparatus, no telephone systems or flashing signal lights, no safety nets or man-tramways. Nevertheless, the construction processes were so basically sound that much of the machine-operated apparatus used by modern suspension bridge builders has as its prototype the crude, often hand-driven devices used by the builders of the Brooklyn Bridge.

The Historical Setting

The Pacific Railroads had just been completed. The effect of this outstanding engineering and economic venture of the period on the growth of New York City had been stressed by John A. Roebling in his promotion of the East River Bridge, as the Brooklyn Bridge was first called. As they ate their lunch in the Bridge's noisome caissons, the builders undoubtedly rejoiced that Boss Tweed was at last headed for jail and deplored the fact that some persons had coupled Tweed's name with their East River Bridge. They talked of a device that would relieve folks of writing their business letters in longhand: the typewriting machine. Some of them went to the Centennial Exposition at Philadelphia in the year when the cable-spinning apparatus was started on the Bridge, and there they watched Alexander Graham Bell exhibit his pioneer telephone. Frequently they read of Indian raids in the Great West. These bearded young bridge builders must have grieved at the assassination of President Garfield, which occurred about the time that the floor system of the Bridge was erected. Proudly they watched Garfield's successor, President Chester A. Arthur, lead the procession



Harper's New Monthly Magazine

Relentless in his exacting energy, John August Roebling was a hard but inspiring taskmaster. After his untimely death his associates did him the highest honor possible by completing the Brooklyn Bridge according to his high standards.

[1] The bill for candles at the Brooklyn caisson was about $2,500, more than half the total cost of the calcium, candles, and gas for caisson lighting, exclusive of apparatus.

Harper's Weekly

Forty million East River ferry tolls were collected annually at the time the Bridge charter was granted. A map published when the Bridge was completed shows 15 ferry lines; and 100 various craft an hour crossed the line of the Bridge during the cable-spinning operations. It was a busy East River.

of notables across the completed Bridge in 1883.

Exciting political events and outstanding inventions thus marked this period of virile American expansion — the 16 years of planning and building the Bridge. Doggedly its builders kept at their tasks, too fanatically determined to complete this seemingly endless enterprise to realize that they, too, were making history — of a quality that would inspire bridge builders of succeeding generations.

The Characters

Of the nine Bridge engineers whose names appear on the tablet of the weathered Brooklyn tower, only the three principal executives need be mentioned here: John August Roebling, his son, Colonel Washington Augustus Roebling, and Charles Cyril Martin.

John August Roebling was a bitterly brilliant personality, an immigrant from Thuringia, who had invented wire rope and then established a thriving business in its manufacture. He was, as well, a pioneer builder of American suspension bridges, and when appointed chief engineer of the East River Bridge in the year 1867, he was recognized as the country's most eminent bridge builder. To his credit were structures of the novel Roebling type at Pittsburgh, Cincinnati, and Niagara Falls, but the East River Bridge was to be his masterpiece! The basic design was his, but an accident before actual construction was started caused his death. His son, Washington Roebling, was appointed chief engineer and saw the completion of the Bridge which his father had planned.

One of America's dramatic sagas is the story of how the younger Roebling (during his invalidism which resulted from caisson disease incurred on the work) followed the Bridge construction from his bedroom window by telescopic observations with the help of his wife (the sister of his Civil War commander, Major General G. K. Warren). His reports during his sickness are models of engineering good judgment, but the active construction must be credited to his assistants, and particularly to Charles C. Martin, the principal assistant.

Martin had the unique record of 33 years of activity on the Brooklyn Bridge: first during its building, then as chief engineer and superintendent, and later as consulting engineer of the Department of Bridges, New York City. Vice-president of the American Society of Civil Engineers and the recipient of a unanimous vote of the alumni of Rensselaer Polytechnic Institute to be head of that college, which honor he declined, Martin chose to remain associated with the Brooklyn Bridge until his death.

The Economics of the Bridge

John A. Roebling promised handsome profits to investors in the East River Bridge project. One source of income would come from rental of treasury vaults which could be built within the New York anchorages and which would "soon be filled with three-fourths of all investments and securities now held in this country." The increase in the valuation of Brooklyn real estate due to a bridge would amortize its construction cost in three years, he said. Competing for funds in a time when American speculation reached a peak, clever promoter John A. Roebling made superlative claims. History shows even his most extravagant claims to have been understated, for few public enterprises have paid off as handsomely.

A comparison of the Brooklyn Bridge toll schedule of 1884 with that of the George Washington Bridge nearly half a century later gives an indication of bridge revenues and, incidentally, provides an insight into transportation habits of the times.

Horse-drawn vehicles and the cable-car railroad provided the prime source of revenue for the Brooklyn Bridge; automobiles are the largest source of revenue for the George Washington Bridge. The present toll for pedestrians is 10 times that for the foot passengers of six decades ago. This comparison is of little significance in indicating the revenue from pedestrians, for two reasons: As a result of increased prices and wages, the dollar has much less purchasing value now than it had then. As an example of the general increase in wages over the past half century it is interesting to note that bricklayers in New York City receive about four times the hourly rate they did in 1884. Furthermore, tolls from foot traffic are a small part of the income for the George Washington Bridge, whereas the popular promenade of the Brooklyn Bridge had tremendous traffic.

COMPARATIVE TOLL SCHEDULES

Brooklyn Bridge (1884)		George Washington Bridge (1931)	
Foot passengers	1 cent	Pedestrians	$0.10
Railroad fare	5 cents	Passenger Automobiles and Horse-drawn vehicles	0.50 to $0.70
One horse, or horse and man	3 cents	Trucks	0.50 to 1.00
One horse and vehicle	5 cents	Tractors	1.25 to 1.50
Two horses and vehicle	10 cents	Busses	1.00 to 1.10
Additional horses, each	3 cents		
Neat cattle, each	5 cents		
Sheep and hogs, each	2 cents		

Roebling was the first successful promoter of a bridge to Manhattan, if we except the narrow Harlem River crossings. With the Civil War only two years in the past, Roebling naturally stressed the military value of the Bridge in case of war.

Having proved at Niagara Falls that a suspension structure could be made sufficiently rigid to carry railroad trains, Roebling featured a cable-propelled railroad for his East River Bridge. Bridge railroad service to Manhattan is now considered of secondary importance, but the George Washington Bridge has provision for a future, lower railroad deck. The East River ice hazards made competition from the ferries negligible. Competition from tunnels, which finally relieved the overcrowded Brooklyn Bridge in 1908, Roebling treated rather nonchalantly. Tunnels would come ultimately for the transportation of freight, but they would be immensely costly, he predicted. Uncanny prescience on Roebling's part, envisioning the automobile, however, would have been required to have had him make his Bridge traffic lanes of the 20-foot width of those of the Holland Tunnel, instead of their actual width, 16 ft. 9 in.

Roebling's studies of an artery to relieve the traffic of Manhattan Island, with a population approaching 1,000,000, guided later traffic studies for more and more arteries to keep pace with the expansion of the metropolis. He considered the northerly movement of New York traffic in his alternate Bowery-Canal route, which would have terminated where the Manhattan Bridge now ends. The northerly progress of traffic was later emphasized in the schemes for a Hudson River Bridge, which, although authorized only one year later than the East River Bridge (1868), was to wait for more than 60 years before its consummation at the George Washington Bridge crossing at 178th and 179th streets.

Considering the slow tempo of the horse-drawn traffic of Roebling's time, it is obvious that he could not envision the problems and costs of bridge approaches which would still be adequate half a century later. Today, the approaches to a large bridge require a high order of planning and design and may cost more than the bridge itself.

Correctly, Roebling expected heavy traffic on the promenade of the Bridge. The later acquired experience of the crowd-conscious New York police was needed to indicate that steps on the promenade were a serious safety hazard. The Bridge trustees were "reprehensible," according to the coroner in the case of the tragic panic at the New York steps of the promenade, in which 12 persons were crushed to death about a week after the opening of the Bridge.

We may pass over the alternate designs for various elements of the Bridge — cantilever construction versus a suspension span, steel versus wrought iron, wire cables versus bar links — by quoting Roebling's way of settling such problems: "We want the greatest amount of strength for the least amount of money. . . ."

Bridge Design, Circa 1870

We can readily understand the doubt which many expressed as to the safety of the Bridge when we consider the status of suspension bridge design and the small number of suspension bridges in use in the post-Civil War period.

Roebling's greatest contribution lies in his conception of a rigid type of suspension structure, suitable even for railroad trains, and his ability to devise methods of building such a structure. Within one generation the art of sus-

Museum of Modern Art, New York. Photo by Russell Griswold

Structures become out of date quickly in New York City, and millions of dollars are sacrificed to the factor of obsolescence. But old Brooklyn Bridge is by no means out of date; it is still an important traffic artery. The city's postwar plans will preserve the utility as well as the beauty of the Bridge.

Harper's Weekly

The New York approach on opening week. Horses and wagons made up most of the bridge traffic, and shouts and horsewhip gestures signified the drivers' intentions. Bridge trustees had set the vehicular speed limit at four miles an hour.

pension bridge design progressed more than in the previous millennium.

Today's suspension bridges, now pre-empting the field of long-span construction, do not depart materially from the basic features of the Roebling bridge at Brooklyn. Anchored cables pass over towers and support the bridge floor system by hanging wire ropes. Unsafe vibratory effects are avoided by bridge proportions that, when successful, do not differ markedly from those of Roebling. Roebling's achievement is apparent when we consider three factors: the status of the theoretical knowledge of structural design of the Nineteenth Century, the degree to which practical designers were versed in this knowledge, and the limited knowledge of the properties of the materials which he and his successors courageously adopted.

We must not sneer at the theoretical knowledge of structural design in Roebling's time. The rational column theories of Rankine and Euler were available, likewise the equation of the elastic curve of a beam in flexure and the resultant stresses in tension, compression, and shear. It was also known that certain arrangements of members were statically determinate, others indeterminate. It was a far cry, however, from the wide scope of the knowledge that a modern engineer must possess, forswearing guesswork, if his design of a suspension bridge is to consider rationally all the load effects. The engineer of today must understand aerodynamics and vibration analysis, he must possess the mathematical facility to investigate them, and he is coming to appreciate the desirability of scale model wind tunnel tests.

John A. Roebling was versed in the theories of his day, but his successors, who had to evolve the details of his conceptions, gave evidence that they did not possess the facility of the master. They were ingenious, however, and recognized today's basic principles of design, provided for factors of safety, and gave more weight to the elastic limit than to the ultimate strength of their materials.

As to the properties of the new steels — open hearth and Bessemer — we need merely read of the tests that these men devised to agree that their guesses were empirically sound because of their well-planned and well-executed methods of substantiation. Today, the designer has generations of tests back of most of the materials that he uses; then, the designer had to test as he went along.

Like today's designers, the Bridge engineers assumed magnitudes for and the distribution of loads and then selected members to carry them. The details of their Bridge prove their conservatism. First, in the matter of rigidity, horse sense prompted both Roeblings, father and son, to adopt a safe arrangement. Their reports discuss with engineering appreciation the effects of vibration due to moving loads and wind. The recent impressive studies of the aerodynamic stability of suspension structures give ample realization of the need of a rational analysis of such effects, if (*Continued on page 450*)

New York Sun

New Yorkers can now view their old Bridge, unmarred by the hideous terminal which was recently torn down. At each end, Roebling's Bridge concentrated enormous crowds within small areas, until the subway to Borough Hall in Brooklyn in 1908 relieved most of the traffic congestion.

Investing in Science for the Future

New Sources of Venture Capital Extend Opportunities to Build Industries Based on Scientific Discoveries and Encourage Research Workers to Leave the Beaten Path

By W. Rupert Maclaurin

OUR scientists today face the future with great confidence. They believe that over the years ahead a series of important discoveries will pour out of our American universities and will give rise to a host of possible new industrial developments. Given the proper backing, they predict that within 10 years they can harness atomic energy for important peacetime objectives; and they suggest that this is only one example of a series of revolutionary scientific developments which may occur. If these forecasts prove correct, there will be many new scientific industries which will be started in the future as a direct outgrowth of advances in science.

The future can be discussed with more confidence if we understand how past developments have occurred. By using radio as a case study, I should like, therefore, to illustrate the steps which are required to bring a new scientific concept from the theoretical stage to a successful commercial product.

The pioneers of the radio industry were university scientists. Marconi has often been referred to as the father of wireless. This is not the case. James Clerk Maxwell, a mathematical physicist at the University of Cambridge, foresaw, 80 years ago, that wireless waves could be produced, and he gave the complete theory of their generation and propagation long before their existence had been suspected. About 20 years later, another scientist, Professor Heinrich Rudolf Hertz of the University of Bonn, first proved experimentally that electromagnetic waves could be detected through space. He designed a spark-gap oscillator which would generate wireless waves, a metallic mirror for reflecting them, and a loop type of antenna for detecting them. By such means he was able to send and receive signals from one end of his laboratory to the other without an interconnecting wire.

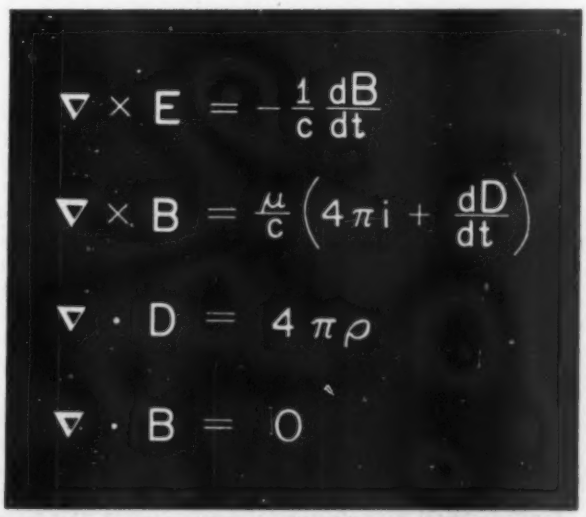
Following Hertz, scientists in various countries turned their attention to the study of wireless communication. But none of these early pioneers were consciously thinking about commercial developments. Their interest was in experimenting with the transmission and reception of magnetic waves through space because this was a new phenomenon of nature which was not yet fully understood.

The other key scientific discovery on which modern radio is based is the thermionic vacuum tube. Thermionic emission of electrons was explored originally as a separate problem of physics with no thought of its ultimate value for the detection of electromagnetic waves. Here there was a very similar course of development in that there was a period of several decades of purely scientific research of a type that would be exceedingly hard to describe as of any practical use. This research came to a climax with the work at the University of Cambridge of J. J. Thomson and especially of his pupil, O. W. Richardson, who finally worked out the theory of thermionic emission of electrons from hot filaments and correlated this emission with the temperature and the physical characteristics of the filament. It was on top of this scientific work that De Forest introduced his three-electrode vacuum tube as a wireless detector.

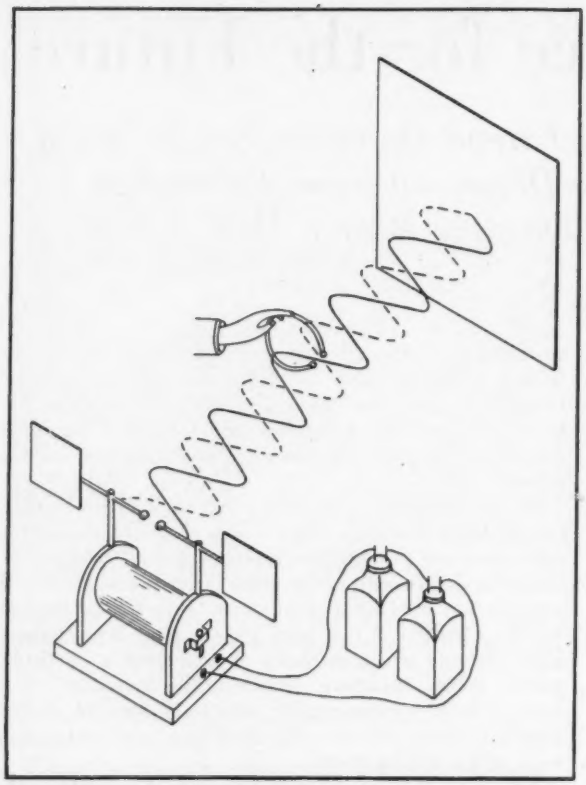
In the story of the process of technological development in the radio industry, there was a clear-cut division of labor between the university physicist and the commercially-minded inventor, who came later. We might note in passing that very few patents were taken out by the university scientists. A new principle of nature is not patentable. Patents cover methods of achieving a particular result. When, therefore, Marconi, the inventor, set to work to build a commercially practical system of wireless communication, he was able to obtain basic patents on most of his developments.

This was the era of the independent inventor. The courts were very generous in granting patents, and advanced scientific training in physics and electricity was not required to make really important contributions.

Without the pioneer work of the university physicist, the practical development of radio communications would have been impossible. Marconi himself did not have the



James Clerk Maxwell, Britain's brilliant mathematical physicist, evolved (about the time of the Civil War) the set of electrical equations (above) bearing his name, based on the experimental work of Ampère, Henry, Faraday, and others. The solution of these differential equations led Maxwell to predict the properties of electromagnetic waves long before their existence was suspected. Thus, our present radio industry has its roots firmly planted in intellectual abstractions.



Heinrich Hertz, German experimental physicist, produced and observed the behavior of electromagnetic waves some two decades after Maxwell's theoretical predictions. In so doing, Hertz not only verified Maxwell's earlier work but discovered means for physically creating the waves which are the heart of radio communication.

background in experimental physics which would have led him to make the discoveries of Hertz. His main scientific contribution was in improving the laboratory type apparatus of his predecessors and making it perform much more consistently. But in terms of practical value to society, this contribution was enormously important.

It is interesting, also, to examine historically the role that established industry played in bridging the gap between the fundamental discoveries made in a university environment and the commercial development of radio. The electrical industry was well organized at the turn of the century when Marconi launched the first radio companies in the world in England and the United States. The American Telephone and Telegraph Company was already an important concern. Western Union and Postal Telegraph had telegraph lines throughout the United States and cable connections abroad. The development of wireless communications was obviously a potential threat to the interests of these companies, particularly to the international cable system. Yet the communication companies made no outstanding contributions to wireless in the early years, and the same can be said of the important electrical manufacturing enterprises at the time. These various companies had their own fields of interest. A new and highly speculative development such as wireless had very little appeal.

What role did venture capital play in launching the radio industry in this country? The three most important early American concerns were the American Marconi Company, the National Electric Signalling Company (Nesco), and the De Forest Wireless Telegraph Company. The American Marconi Company was financed by investment bankers in England and the United States; its stock was largely privately subscribed and held in large blocks. Nesco, financed entirely by two wealthy Pittsburgh capitalists, conducted the first experiments made by any commercial company on the wireless telephone. The De Forest Wireless Telegraph Company, stock in which was sold by high-pressure salesmanship methods as an out-and-out speculation, later went into receivership; but its principal inventor, Lee de Forest, made one of the most revolutionary inventions of the last 50 years — the three-element vacuum tube. Very few of our modern developments in electronics would have been possible without De Forest's historic discovery of the tremendous increase in sensitivity that can be obtained by introducing a third element between the cathode and the anode of a vacuum tube.

These three companies, therefore, were financed with different types of capital: American Marconi with investment money, Nesco with long-term speculation money of wealthy individuals, and De Forest's company with "get-rich-quick" money from many small investors. The Marconi investment ultimately proved very profitable, Nesco broke even, and De Forest failed. The fact that all types of capital were readily available for financing new ventures contributed materially to advancing radio technology.

Not only inventive talent and venture capital were needed for the success of these new scientific enterprises, but also managerial skill. De Forest's vacuum tube was more revolutionary in its ultimate impact than any invention of Marconi's, but Marconi had the help of the best business advice that could be obtained. When, as usual in such new enterprises, difficulties occurred, the directors brought in a business executive of outstanding ability, who took over the responsibility of management, leaving Marconi free to concentrate on research.

Several points may be stressed in this story of the early technological development of the radio industry. They apply not only to radio but to most new enterprises of a scientific character. The first is the vital importance of fundamental research in laying the foundations for the new industry. The second point is that the established electrical-goods industries played an entirely negative role in the early stages of radio development. In consequence, the provision of various types of venture capital was essential to getting the new industry started. Finally, the success of a new scientific venture is dependent on a combination of managerial skill and inventive talent, which is not normally found in any one man.

But what of the future? Are we likely to have a continued flow of fundamental scientific discoveries, comparable in importance to the discovery of Hertzian waves?

It is significant to note that those who made the fundamental scientific advances which gave rise to the radio industry were all Europeans, as has been true of many other industries. Our genius in this country has lain more in applied research and advanced engineering development. We have taken the discoveries of the great European scientists and converted them into practical commercial products with a skill and ingenuity unrivalled anywhere else in the world. But most of the senior physicists of today are Europeans — Einstein, Niels Bohr,

Fermi, and so forth. It was these men and others who were responsible for the original exploration of the atomic nucleus. They have followed in the tradition of Maxwell and Hertz. Their motivation has been the creative intellectual urge to push back the boundaries of our understanding of natural phenomena. The application of these advances, except under the special pressure of wartime service, has been left entirely to others.

In recent years there has been a substantial improvement in our standards of fundamental research in this country. We have been producing more scientists of distinction, like E. O. Lawrence, I. I. Rabi, H. C. Urey, and A. H. Compton, to name but a few. It is vitally important that this trend be encouraged. Even if we chose to do so, we can no longer rely on the intellectual banks of Europe, which have been bankrupted by the ravages of war. It is essential that we should have flourishing long-range research of a basic character, carried on under the best possible environmental conditions. This need has been recognized by the leading scientists of the country. In his report to the President on a program for postwar scientific research, Vannevar Bush, a member of the M.I.T. Class of 1916, has emphasized the prime importance of support to fundamental research in universities. There are now bills before Congress which incorporate the principal recommendations of the scientists. I believe that our leaders in government are aware of the necessity of these recommendations and that suitable legislation will be passed to provide for a continued flow of fundamental scientific discoveries from this country.

Can we rely on our established industries of today to convert these scientific advances into new products and processes as rapidly as possible? I believe the answer to be, no. This statement requires an explanation.

Our well-established industries have made tremendous strides since the turn of the century in their capacity to understand and contribute to science. The electrical industry is far more alert to new developments today than it was at the time of Hertz's experiments. Our great industrial laboratories in such concerns as the General Electric Company, the American Telephone and Telegraph Company, E. I. du Pont de Nemours and Company, and the Eastman Kodak Company have hundreds of distinguished scientists in their ranks, including several Nobel Prize winners.

However, every large, well-established company tends to concentrate on certain fields of special interest. No matter how hard management tries to be receptive to new ideas, the radical notion and the new risk-taking approach are frequently not exploited. I do not wish to be misunderstood on this point. We can rely on our great industrial corporations to take substantial risks and to be foresighted in many areas. But the smaller developments, which are off the beaten track and which are in the speculative stage where their potentialities cannot be predicted, are likely to be neglected.

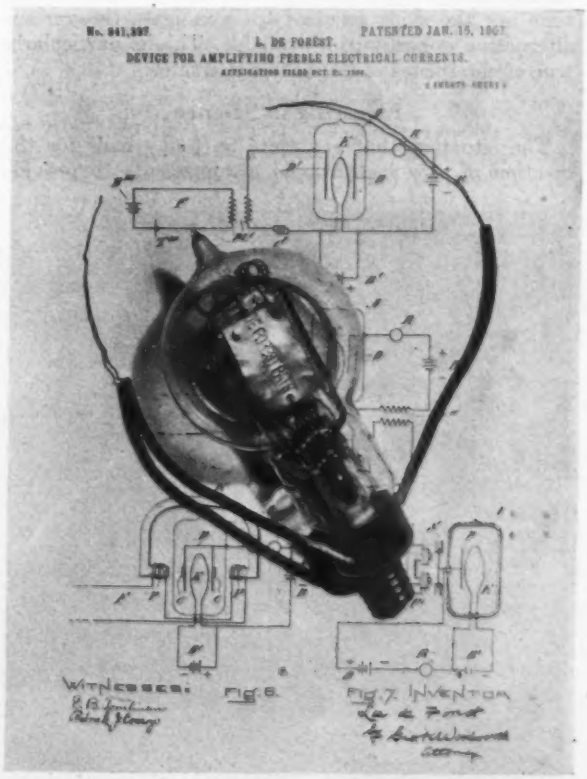
I believe that there will be important opportunities in the coming years for scientists and engineers, interested in the transition from fundamental research to its practical applications, to start new enterprises of their own. And in these ventures I think organized capital has a responsibility and an opportunity to play a significant role.

I see no reason why it should not become generally accepted that organized capital and individuals with capital have duties and responsibilities to the public as to what they do with their money, just as it should be accepted that management and labor have duties and responsibilities to the public in the conduct of business enterprise.

Industries Based on Science

We need new scientific industries launched, and we need them launched under the most favorable auspices. Investment tradition in this country strongly favors the seasoned and well-established company. This conservative approach has been justified by the record of new companies. Although there have been spectacular successes, there has also been a very high mortality, with the result that the most reputable investment banking institutions shy away from underwriting new ventures. Moreover, the expenses involved in public flotation are too great for the new company that needs only a small amount of capital. Such enterprises, therefore, are generally deprived of the guidance and managerial experience that the well-established investment banker is in a position to offer.

Nor have they been able to obtain capital directly from institutional investors. It has not been considered sound practice for investment trusts or insurance companies to invest in unseasoned securities. In fact, until very recently it has not been legal for investment trusts which engage in selling their own shares to the public to buy securities in companies which have not been in existence for a stated number of years. All those states where there had been prohibitory regulations, however, have now modified their



Lee de Forest, American inventor, built the first three-electrode tube about 40 years ago. In so doing, De Forest made one of the most significant contributions to practical radio communication, for the modern version of the early three-electrode tube (shown above) forms the basis of nearly all electron tubes used in radio reception and transmission.

regulations so as to permit modest participation in new enterprises.

In the case of life insurance companies, the laws are also being liberalized. For example, the state of Connecticut has recently amended its statutes to permit investments up to 5 per cent of assets, free of all legal restrictions. Although the state of New York has not yet followed suit, there is no prohibitory law in Massachusetts or in many other states. The aggregations of capital controlled by investment trusts and by most life insurance companies are, therefore, no longer prevented from playing their part in providing funds for new enterprises.

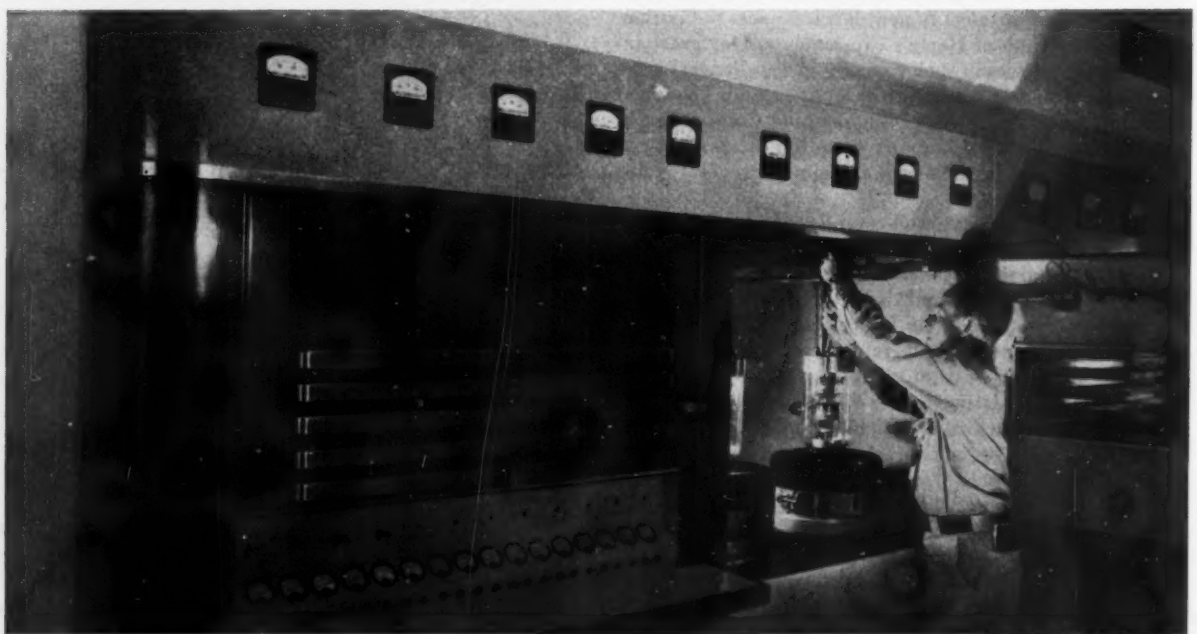
Typically, however, the small new concern still has to rely on individual investors for capital. In the days when American Marconi and Nesco were launched, there were many wealthy individuals who were willing and able to put capital into new ventures. With tremendous increases in taxation, however, the number of such individuals interested in speculative long-term investments dwindled rapidly. Today, there is once more a revival of interest in speculation. The Excess Profits Tax Law has been repealed, and long-term capital gains are taxable at not over 25 per cent. A man who is in a high income-tax bracket can now increase his wealth through investments in enterprises which have an opportunity for substantial appreciation over a period of years. But there is no effectively organized machinery whereby individuals with money to invest in such enterprises can get adequate diversification of risk, and most investors have neither the time nor the skills required to investigate the various alternative opportunities available. This is particularly true of enterprises of a scientific character.

Investing in Science

The situation that confronts us today calls for the creation of new institutional arrangements to provide venture capital. One promising suggestion that has been made is to establish a number of investment companies or holding companies in different parts of the country, the sole function of which will be to seek out, investigate, and finance new ventures. Such development companies could afford to employ professional staffs to investigate new enterprises. They should serve as receiving stations for ideas that have reached a point where the need for capital can be demonstrated, but where the requirements are not large enough to be handled by investment bankers. They could draw on experts from the universities and elsewhere as consultants and could build up a background of managerial experience in new enterprises which would be extremely helpful to the young entry. Assuming the life insurance companies and investment companies are sufficiently interested, the organization of such institutional arrangements can be greatly facilitated by the Securities and Exchange Commission, if that body chooses to encourage such an objective.

I am hopeful that life insurance companies, investment trusts, and other large institutional investors will now be willing and able to invest a small proportion of their surpluses in development companies of this character. The volume of capital in the hands of institutional investors in this country has been growing steadily and has already reached staggering magnitudes. Unless some small part of those funds can be applied to new and untried ventures, the search for security, which has led to the phenomenal increase in insurance and to the growth of management trusts, will prove a millstone around our necks and inhibit further economic progress.

It would be a mistake to conclude that the bottleneck is merely one of capital or that all that will be needed is venture-capital companies with adequate funds and staff to investigate new scientific proposals. I doubt if this set-up would be successful (*Continued on page 452*)



Westinghouse Electric Corporation

Frank Conrad, American electrical engineer, inaugurated the first regularly scheduled radio broadcast programs, thereby completing the last link in a group of scientific and engineering achievements upon which the broadcast industry is founded. The transmitter shown above is that of the historic station, KDKA.

The Scientist's Social Responsibility

Promise for the Solution of Many of Man's Problems Lies in Extending the Application of the Scientific Method to the Problems of Society

By Francis Bitter

OUR world is continually upset by discovery and invention. No sooner do we begin to settle in some semisatisfactory pattern of living than some new factor is injected into the picture and upsets one or another of the delicate balances of conflicting aims and desires which make up our civilization.

The latest culprit is the scientist. The atomic bomb particularly has focused the attention of the entire world upon him and is forcing him to consider as never before what his role may be in shaping our common destiny. On the one hand, society supports him on an increasingly lavish scale, urging him on from one success to another. On the other hand, his discoveries have serious consequences, sometimes obviously alarming, sometimes subtle and difficult to foresee. What can the scientist do about this situation? Should he give up, to some extent, his singlehearted devotion to his chosen work and undertake a study of new problems which are not professionally his?

The following three propositions, if accepted by the reader, are sufficient for us to draw a few conclusions regarding the proposed question.

(1) Responsibility is inseparable from ability.

(2) It is the responsibility of any group, particularly one supported by the public, to make certain that its special knowledge is made available to society and to do this in such a way that the implications of this knowledge may be as fully and as generally understood as possible. In times of emergency or danger it is the responsibility of such a group not only to make knowledge available but to perform for the community services for which professional specialists have not yet been trained.

(3) Applied science is important primarily in helping us find means to an end, rather than in determining which among various possible ultimate ends we wish to achieve.

From the point of view of these propositions the record of the scientist is apparently good. In war as in peace he has not only made his special knowledge generally available but has helped apply it to the urgent problems of the community.

If there is any cause for complaint, it is that the scientist has restricted the range of his interests too much. Particularly before the war the scientist was content to focus his attention on one small aspect of the physical behavior of matter, and to some extent this is true today. Subconsciously, perhaps, he assumes that all aspects of human experience are covered by a variety of specialists and that he is merely doing his share in a majestic all-inclusive research. This kind of isolationism is likely to lead to a lack of balance in the intellectual development of society. It is quite possible that some of our major ills are due to this cause. The existence of certain categories of human misery in spite of known remedies certainly suggests that we have more knowledge than we sometimes use.

In the face of this situation, it seems a pity that so much attention is being devoted to science as a subject — *i.e.*, the study of the physical universe — and so little to science as a method — *i.e.*, the technique of collecting and manipulating quantitative data. It is unlikely that coming generations will be as grateful for a few more technical inventions as they would be for a deeper insight into the causes of our collective insecurity.

During the war a few scientists had unusual occasion to appreciate the wide range of applicability of their methods and techniques. The use of the scientific method — the objective and quantitative analysis of a problem, supported by controlled experiment wherever possible — proved eminently successful in analyzing situations involving not only material objects but the human element as well. The "operations analysts," as they were sometimes called, proved extremely useful in showing how to deal with certain military problems more quantitatively and accurately than had heretofore been possible. In addition, they themselves acquired an insight into the potential value of their point of view and technical skill in a wide range of problems. New opportunity revealed a new skill, and this in turn brought with it an important new responsibility of the scientist, which responsibility it is the purpose of this article to discuss.

That the methods of mathematical analysis are applicable to a wide variety of problems is not a particularly new thought, but two surprises were in store for the operations analysts and their employers. The analysts were surprised to find an almost complete absence of mathematical "feel" on the part of those responsible for formulating policy. The administrators, on the other hand, were surprised that sufficient data could be collected to make quantitative analytical methods applicable. There was, then, this remarkable situation which we shall find again in other fields: On the one hand, administrators who were ignorant of, and often prejudiced against, quantitative methods; on the other hand, skilled analysts who were unaware of the need of the community for the application of quantitative analysis and reasoning — in short, application of the scientific method. During the war scientists and engineers were made aware of this need through the medium of the equipment which they designed. They were asked to consult on its use and so came into contact with operational data. Once in this field, they found it fruitful to go on to consider other more general operational problems.

The war emergency is now over, and specialists have been trained who can take over this new kind of work for the armed forces. Perhaps some of the effort that was

Farmer's Return — *Mildred Hatry*

No sooner do we begin to settle in some semisatisfactory pattern of living than some new factor is injected into the picture and upsets one or another of the delicate balances of conflicting aims and desires which make up our civilization.

diverted from normal pursuits to the winning of the war should now be devoted to tackling the new problems which currently confront us.

Knowledge Not Fully Utilized

All these problems seem to center around the sensible exploitation of the skills and knowledge which mankind has acquired. A proper use of atomic energy is but one of these. Our present knowledge of disease, food production, or manufacturing, for example, offers greater potentialities for services to mankind than are realized. The difficulties in the way of sensibly exploiting our assets may well be prodigious, but surely the importance of new light in this field is so great that we should devote more and more effort to it, in spite of the difficulties, rather than transfer our attention to problems which are apparently simpler and more immediately rewarding.

If we consider the three propositions on social responsibility, it appears that the scientist may have a responsibility toward society which he is not fulfilling. He is unquestionably doing a great deal in revealing facts and formulating concepts about the nature of the physical world. He certainly cannot step completely beyond his field and tell us what is good and what is bad, what we ought and ought not to do. That is the task of other specialists. But between these extremes there is a range of problems of the greatest practical importance to us all — quantitative problems of considerable complexity — in which the methods and techniques of science may indicate new approaches.

What then, are these problems, and how might the scientist find solutions for them? Before answering this question, let us reflect for a moment on some of our social problems.

It is clear that the people who are at present running the world — who determine its industrial, economic, technical, political, and every other kind of pattern — are doing less than a perfect job. It is also clear that the difficulties which face these men do not arise exclusively from conflicting motives. In at least some important instances there could be agreement on motive, but there is lacking a convincing demonstration as to what constitutes adequate means.

In 40 years almost all today's leaders will be dead or retired, and their places will be taken by the new generation which is now preparing for the job ahead. It is through the schools and colleges that scientists might most suitably and effectively contribute to the solution of social problems in educating the newer generations of students. It is in the educational institutions that we find proper conditions for research and study, that there are specialists in all the relevant fields of learning, and impressionable minds eager to take up new and promising ideas. It is here, also, that the scientist as a teacher already is charged with the responsibility not only of teaching his students how to earn a (*Continued on page 438*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

. . . *Honored* . . .

THE Medal for Merit, the highest of the awards which can be bestowed only on civilians, was presented to President Compton by Lieutenant General O. W. Griswold, commanding general of the First Service Command, on April 2.

The ceremony, which was held in Dr. Compton's office at the Institute, was witnessed by Mrs. Compton, Lieutenant Colonel John C. Dunbar, '25, Head of the Department of Military Science and Tactics, and members of the Institute's administrative council. The citation of the award, signed by President Truman, follows:

Dr. Karl Taylor Compton, member of the National Defense Research Committee, from 27 June 1940 to 2 September 1945, and Chief, Office of the Field Service of the Office of Scientific Research and Development, from 11 October 1943 to 30 July 1945, for exceptionally meritorious conduct in the performance of outstanding services to his country. As Chief of the Office of Field Service, Dr. Compton mobilized and made available to the needs of the armed services civilian experts in various scientific branches who assisted in the introduction into use within theaters of operations of new weapons, devices, and techniques developed by the Office of Scientific Research and Development and others. Through his vision in the formulation of the program of research and development of microwave radar and his steadfast support of that program, Dr. Compton contributed greatly to the technical superiority of the Allied forces in this field. Under his direct leadership, the programs of research and development of the United States and the United Kingdom were integrated for a maximum effectiveness in the radar field. The importance of this work was such that Dr. Compton may be said to have been personally responsible for hastening the termination of hostilities.

In accepting the medal, Dr. Compton replied:

General Griswold: To you as representative of the Commander in Chief I express my most sincere appreciation for this great honor. To me it will always be a symbol and reminder of the wonderfully fine teamwork which developed to such a high state of effectiveness during the war involving the cooperation between a very fine group of scientists and a very fine group of military personnel.

I am especially happy to have received this medal at your hands because I recall our association in Manila last August amid the siege of the city and country whose return to freedom was due to such an outstanding degree to the fine work of the Fourteenth Army Corps under your command.

It was this military achievement which brought the final consummation to General MacArthur's earlier promise to the Filipinos: "I shall return."

I trust, sir, that you will convey to the Commander in Chief my sincere appreciation of this honor.

. . . *Selective* . . .

IN attendance at the 249th meeting of the Alumni Council, held in Pritchett Hall of Walker Memorial on March 28, were 93 members and guests. In the absence of President A. Warren Norton, '21, Vice-president Alfred T. Glassett, '20, presided and quickly passed through the business session, in which the customary reports were presented. Henry B. Kane, '24, Director of the Alumni Fund, reported that approximately $165,000 in contributions have been received from more than 10,000 Alumni during the past year, thereby reaching the goals set for number of contributors and amount of contributions.

Robert E. Barnhart, one of the Institute's married veteran students in Course XVI, was introduced by Vice-president Glassett. Mr. Barnhart is in the second term of his freshman year and, together with Mrs. Barnhart, became one of the early residents of Westgate, the Institute's housing community for veterans who have returned to M.I.T. for study. Mr. Barnhart gave a terse, meaty, witty, and highly entertaining talk on highlights of life at Westgate.

President Compton then discussed certain phases of the administration budget and gave comparisons of figures for

International News Photo

"For exceptionally meritorious conduct in the performance of outstanding services to his country," the Medal for Merit was awarded to President Compton by Lieutenant General O. W. Griswold.

the present year with those of earlier periods. It was particularly striking that figures of expenses and income are continuing to grow.

The final speaker of the evening was Professor B. Alden Thresher, '20, Director of Admissions. His talk was particularly timely in view of the extraordinary increase in correspondence, inquiries, and applications since the end of the war.

Professor Thresher traced the development of the Institute's policy from one of "automatic" to one of "selective" admission and indicated the important part played by the Institute's 200 Honorary Secretaries, who serve as counsellors to prospective students and aid the Admissions Office through reports on candidates. Through their co-operation, the selectiye process is partly decentralized and made effective over a wide area.

He emphasized the importance of weighing each case on its merits and of deferring a decision until the evidence is all in hand, and he spoke of the difficulty of reconciling this policy with the natural desire of every candidate to know as early as possible what his chances are.

The rush of applications from veterans has brought many new problems. Some 55 members of the teaching staff have co-operated in giving part-time service interviewing veterans who call in person. It is of the greatest importance that each of these candidates should be able to talk over his problems fully with a responsible officer of the Institute. The many who cannot be accepted can thus be assured of a careful hearing and informed advice on their educational problems.

The Institute's policy of giving priority to its former students returning from the service has made it necessary to cease accepting for work in science or engineering any new candidates who have had a start in college work elsewhere. Most of these can return to the colleges they previously attended and are encouraged to do so.

The freshman class next September will number 900, including some who will start their freshman year in June. This total will be divided between 1946 secondary school graduates and veterans.

It is estimated that in the 12 months following V-J Day more than 10,000 veterans will have been interviewed at the Institute and 75,000 new inquiries about admission will have been answered. Actual application, although not of this order of magnitude, remains far above the Institute's capacity, even after the 50 per cent increase in enrollment already authorized.

Reunion Plans

Plans for Class Reunions, in many cases the first since the war began, have been announced by the following Classes:

1886	Probably no reunion will be held.
1888	Thompson dinner tentatively set for May 11, Engineers Club, Boston.
1891	June 7–9, New Ocean House, Swampscott, Mass.
1896	June 6–7, East Bay Lodge, Osterville, Mass.
1899	Class will undertake to sit together with ladies at the luncheon and banquet on Alumni Day, June 8.
1901	June 6–7, New Ocean House, Swampscott, Mass.
1905	June 21–23, East Bay Lodge, Osterville, Mass.
1906	Plans under way for reunion during the latter part of June. Details later.
1910	June 5–8, place to be announced later.
1911	May 31–June 2, East Bay Lodge, Osterville, Mass.
1915	June 13–16, Cape Codder Hotel, Falmouth, Mass.
1916	June 14–16, East Bay Lodge, Osterville, Mass.
1920	June 14–16, Sheldon House, Pine Orchard, Conn.
1921	June 9–10, East Bay Lodge, Osterville, Mass.
1924	June 8, headquarters room at Hotel Statler, Boston.
1926	June 22–23, Wianno Club, Osterville, Mass.
1931	June 15–16, Saybrook, Conn.
1935	Plans under way for reunion in early part of September. Details later.
1936	Stag banquet in Boston on June 7 and also possible assembling somewhere on June 9. Further information later.
1941	Probably banquet in Boston on June 7 and very likely assembling on June 9. Further information later.

Additional information will be available from Class Secretaries

. . . *Alumni Day—June 8* . . .

PRE-WAR festivities will be revived for Alumni Day 1946 when Alumni will gather at the Institute on Saturday, June 8, for an inspection of exhibits illustrating some of the Institute's contributions to the winning of the war, a luncheon in the Great Court, a symposium on "The Technology of International Peace," and — winding up the day's activities — the popular Stein-on-the-Table Banquet at the Hotel Statler.

In renewing the Alumni reunion symposia, which were reluctantly omitted during the past five war years, internationally known authorities will speak on different aspects of "The Technology of International Peace" in keeping with the thought that science and technology have their proper place in peace as well as in war.

Photographic exhibits, especially prepared for Alumni Day, will portray the research and training activities in which the Institute engaged during the war and will illustrate devices that helped bring about a victorious peace. An innovation will be made this year by inviting wives of Alumni to attend the banquet.

Detailed plans have not yet been fixed with finality, but the program is rapidly taking shape as the result of much hard work on the part of the several committees. Devoting sufficient time from his regular duties as head of the Department of Food Technology to serve as general chairman, William L. Campbell, '15, announces the program for Alumni Day as follows:

10:00 A.M. to Noon
Registration of Alumni and guests in the lobby of Building 10, M.I.T., inspection of photographic exhibits portraying the Institute's activities in research and training during the war, and visits to Departments.

12:30 P.M.
Luncheon in the Great Court, to which wives of Alumni are invited.

2:30 P.M.
Symposium on "The Technology of International Peace," Walker Memorial.

7:00 P.M.
Stein-on-the-Table Banquet, Hotel Statler, Boston. As usual, seating will be by Classes. Wives of Alumni are invited to attend.

M.I.T. Photo

This recent aerial photograph of the Institute shows, beyond the main dome, many new structures erected during the war. After having housed the Navy's V-12 students, the former Riverside Hotel is once more in use as the Graduate House.

Symposium and banquet speakers will be announced in the June issue of The Review when the final program has been completed. Acceptances already at hand are sufficient to assure that the high caliber of former symposia will be maintained.

A capable and hard-working group of committees is now actively engaged in putting the finishing touches to Alumni Day plans in the expectation that the first post-war Alumni Day Reunion will set a new record in attendance and good fellowship. Chairmen of the committees are as follows: *Ladies:* Mrs. Leicester F. Hamilton; *Ways and Means:* Horace S. Ford; *Transportation and Hotels:* Emmons J. Whitcomb, '11; *Publicity:* Ralph T. Jope, '28; *Exhibits:* Herbert L. Beckwith, '26; *Arrangements for Symposium:* Edward R. Schwarz, '23; *Luncheon:* John B. Wilbur, '26; *Banquet:* Parke D. Appel, '22; and *Registration:* Wolcott A. Hokanson.

. . . *Advancement* . . .

FACULTY promotions and appointments of new members of the staff at the Institute for the academic year 1946–1947 were announced recently by President Compton.

Five well-known associate professors have been advanced to the rank of professor. They are: Richard S. Bear, Department of Biology; Gordon S. Brown, '31, Department of Electrical Engineering; Morris Cohen, '33, Department of Metallurgy; Victor F. Weisskopf, Department of Physics; and Robert S. Harris, '28, who has transferred from the Department of Biology to the Department of Food Technology.

Twenty assistant professors promoted to the grade of associate professor are: Joseph Bicknell, '34, Department of Aeronautical Engineering; Richard H. Bolt, Department of Physics; Lynwood S. Bryant and Paul M. Chalmers, Department of English and History; Albert G. H. Dietz, '32, and Howard R. Staley, '35, Department of Building Engineering and Construction; Allan T. Gifford, '27, and Charles H. Norris, '31, Department of Civil and Sanitary Engineering; Albert C. Hall, '37, and Charles Kingsley, Jr., '27, Department of Electrical Engineering; Lawrence J. Heidt and Walter H. Stockmayer, '35, Department of Chemistry; Kurt S. Lion, Department of Biology; Charles A. Myers, Department of Economics and Social Science; Eric Reissner, '38, Raphael Salem, Henry Wallman, and Samuel D. Zeldin, Department of Mathematics; Gerald B. Tallman, Department of Business and Engineering Administration; and Glenn C. Williams, '42, Department of Chemical Engineering.

Members of the staff promoted to the rank of assistant professor include: Robert L. Bishop, Department of Economics and Social Science; Malcolm S. Burton, '43, Louis F. Coffin, Jr., '43, Harry Majors, Jr., 10–44, Frank J. Mehringer, '41, and Lucien R. Vianey, 6–45, Department of Mechanical Engineering; Donald P. Campbell, '43, and Henry J. Zimmermann, '42, Department of Electrical Engineering; Stuart Edgerly and Thomas H. D. Mahoney, Department of English and History; George T. Johnson, Department of Biology; Robert W. Kennedy, Department of Architecture; Philip R. Wallace, Department of Mathematics; and George A. Znamensky, Department of Modern Languages.

New appointments to the rank of associate professor include; Walter H. Gale, '29, Department of Aeronautical Engineering; William R. Hawthorne, '39, Department of Mechanical Engineering; Albert G. Hill, Department of Physics; Witold Hurewicz, Department of Mathematics; Albert R. Kaufmann, '38, Department of Metallurgy; and Ian M. Stewart, '37, Department of Chemical Engineering.

New assistant professors are: Frank K. Bentley and William E. Weems, Department of Aeronautical Engineering; Donald B. Broughton, '39, John C. Quinn, '35, and Alexander M. Smith, 2d, '43, Department of Chemical Engineering; Thomas M. Hill, Department of Business and Engineering Administration; Elting E. Morison, Department of English and History; William A. Leary, '35, David A. Mooney, '34, F. Everett Reed, Jr., '39, Warren M. Rohsenow, and Milton C. Shaw, Department of Mechanical Engineering; Stuart T. Martin, Jr., '34, Department of Electrical Engineering; and George E. Valley, Jr., '35, Department of Physics.

Appointed to the grade of instructor were: Anthony P. DiVencenzo, John G. Linvill, '43, William K. Linvill, 6–45, Fred I. Magee, Henry C. Maulshagen, Edward J. Rhoad, Jr., William L. Root, '43, and Ernest B. Therkel-

sen, '38, Department of Electrical Engineering; Horace C. Buxton, James Duesenberry, Lionel W. Mackenzie, Jr., and Robert V. Rosa, Department of Economics and Social Science; Myle J. Holley, Jr., '39, and Ariel A. Thomas, '36, Department of Civil and Sanitary Engineering; Joseph A. Polack, '43, Department of Chemical Engineering; Thomas J. Kent, Jr., '43, Department of Architecture; Harold W. Wyatt, '43, Department of Mechanical Engineering; and Eugene Pare, Section of Graphics.

. . . *Visiting Committee Report* . . .

THE Committee on the Department of Aeronautical Engineering* met at the Institute on August 17 for the purpose of inspecting the facilities available for instruction and research in aeronautical engineering and to discuss with the faculty of the Department their plans for the future. After a full day at M.I.T., the Committee met in the evening and considered its findings and recommendations. The findings are:

(1) The effect of the war is to enhance vastly the importance to the country of aeronautical engineering. It is estimated that some 5,000,000 persons, either in the armed forces or in industry, have been directly concerned with the airplane. Technological advancement has been abnormally rapid. Both civil aviation and national security indicate a strong demand for aeronautical engineers. Returning veterans, discharged war-plant workers, and the new generation of students already show a desire for professional training in aeronautical engineering in numbers probably beyond the present capacity of the educational institutions.

(2) It is probable that the state universities and vocational training schools will greatly expand their facilities for aeronautical education. Expansion plans are known to be in hand at Purdue and the universities of Illinois, Minnesota, Maryland, Michigan, California (Los Angeles), North Carolina, and Texas. In Great Britain an Empire Air College is to be established by the labor government on an elaborate scale. Such plans imply mass education in some instances of a type that M.I.T. cannot handle.

(3) There will be an insistent demand from industry, government agencies, and the armed forces for aeronautical scientists and engineers of the highest competence. Some will be needed for design, others for research and teaching. Some are needed for the air frame, others for its propulsion and control. There will be a need for both specialists and engineers with a broad foundation in the aeronautical sciences.

(4) There will be a shortage of courses for the professional training of young men to be leaders in this exacting field of technology. In the past, only the California Institute of Technology and M.I.T. have offered comprehensive training at the highest graduate level. Harvard and Princeton have recently inaugurated special aeronautical

(*Continued on page 434*)

* Members of the Committee for 1945–1946 are: Gordon S. Rentschler, chairman, Godfrey L. Cabot, '81, Charles H. Chatfield, '14, George J. Mead, '16, Theodore P. Wright, '18, Ralph S. Damon, and George W. Lewis.

Members of the Chungking M.I.T. Club, numbering about 70, include graduates from the Classes of 1913 to 1941 and represent Courses I, II, III, IV, VI, VIII, X, XI, XII, XIII, XIV. Officers of the club are Yu Hsiu Ku, '25, VI, President, Turpin Hsi, '14, XI, Vice-president, and Chia Hua Huang, '27, IV, Secretary-Treasurer. Members of the club shown here are: (Back row standing, left to right) Hsi Mou Li, '19, VI; Charles Wang, '39, VI; Nyan-Sing Lieu, '41, II; Tzeng Jiueq Suen, '35, X; Jarvis Tzu Hsiang Huang, '24, XII; George Moy Orne, '31, VI; Tsung-Shu Hsu, '25, X; Tse-Sing Sih, '18, I; David Henry Kiang, '31, VIII; Sung-Sing Kwan, '19, IV; Norman Fook Cheung Li, '38, VI-C; Tsun-Tsing Chang, '35, VI; Kow Kwong Choong, '38, II; Chia Hsu Hou, '38, VI. (Middle row sitting, left to right) Chou Wang, '16, XIII-B; Ren Shou Hsu, '38, I; Chee-Sing Hsin, '14, XIII, XIII-B; Ming Tsai Hsu, '13, X; Chien Hsun Sung, '17, XIII; Turpin Hsi, '14, XI, Vice-president; Colonel Robert F. Seedlock, '40, I; Kwei Lun Hsueh, '18, III; Chi-Che Chu, '16, XIII; Ziang Yien Chow, '15, XI. (Front row sitting, left to right) Sheng Heng Fang, '38, VIII; Chi Foo Yeh, '17, XIII-B; You Yung Wu, '37, XVI; Kuang-Piao Hu, '19, VI; Ping Yok Loo, '16, II; Poh Yuan Hu, '17, III; Ming Hsing Pai, '20, VI; Ko-Chi Chang, '21, II; Chia Hua Huang, '27, IV, Secretary-Treasurer; and Jung-An Lo, '21, II. This list of names was transmitted from C. H. Huang, Secretary-Treasurer, through Colonel Seedlock, who recently advised that the Chungking Club had been carrying on with its regular meetings throughout the entire period of the war.

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engineering courses, and others may become established.

(5) The Committee finds that facilities and staff at the Institute are adequate to handle a reasonable number of high-grade undergraduate four-year-course students in Aeronautical Engineering (air frame) and in Automotive Engineering (engines). In the Graduate School, M.I.T. can offer superior opportunities in instrumentation and control devices, aeroelasticity, structures, stability and control, and engines and thermodynamics.

(6) The Committee worked with the staff in developing a plan for a gas turbine laboratory provided with a supersonic wind tunnel and associated research and testing equipment. The Committee assumed the responsibility for obtaining funds for this facility, and the following have made contributions in response to this effort: Alfred P. Sloan, Jr., '95, the General Electric Company, the Westinghouse Electric Corporation, the Curtiss-Wright Corporation, the United Aircraft Corporation, and the Hooven, Owens, Rentschler Company. The Committee believes that these facilities, provided adequate staff is added at the same time, will give the Institute an excellent opportunity to attract graduate students for work in this new and revolutionary field of propulsion and power generation.

(7) The Committee was informed of plans to modernize the machine tool laboratory and the engineering laboratories of the Department of Mechanical Engineering and heartily endorsed such moves. The Committee is of the opinion that the obsolete machine tools of World War I design are entirely inadequate for the instruction of aeronautical engineering students in the possibilities and limitations of modern machine tools.

(8) The Committee believes that unlimited enrollment of undergraduate students or groups of student officers may so occupy facilities and staff that instruction and research in the Graduate School will suffer eclipse. The Committee believes that teaching and research in the Graduate School are of first importance to M.I.T. and to the country.

Recommendations of the Committee are:

(1) That the plans of the Department of Mechanical Engineering to enlarge and modernize its machine tool laboratory be implemented and that the immediate replacement of obsolete tools be considered a necessity.

(2) That the plans for a gas turbine laboratory with accessory equipment for supersonic aerodynamics are unanimously endorsed, if additional staff are supplied.

(3) That additions to the teaching staff be made to strengthen graduate work in aerodynamics.

(4) That the undergraduate course continue to be based on the fundamental subjects of mechanical engineering and the essentials of airplane design.

(5) That consideration be given to selecting students of scientific aptitude in their senior year for a modified program leading into the Graduate School.

(6) That undergraduate enrollment be limited to promising students and to such numbers as will permit the staff to devote adequate attention to graduate students and research.

(7) That graduate enrollment be limited to superior students, that the number of foreign students be kept small in proportion, that special officer students be limited to those adequately prepared, and that the number of graduate students in any special field be limited by the capacity of the staff and the special facilities available to them. In general, we recommend that graduate students should have free access to the leading professors and should participate in their research.

(8) That undergraduate students in Course XVI wishing to include gas turbines, engines, and combustion be required to enter the Graduate School for a fifth year.

(9) That undergraduate students primarily interested in power plants register in Course II and that those primarily interested in air transportation register in Course XV. Likewise we recommend that undergraduates primarily interested in manufacturing, materials, fuel, and other special aspects for the aeronautical industry register in appropriate Courses, other than Course XVI. Such students registered in other Courses should be allowed to take aeronautical subjects only to the extent that facilities are available.

Our final over-all recommendation is that the Department be now considered to have greatly increased importance to M.I.T. and to the country and that it be strengthened in every way to insure a position of unquestioned leadership. Such strengthening should come first in staff and subsequently in special facilities needed for the Graduate School. Limitation of enrollment is essential to high quality.

. . . *Centennial* . . .

ONE hundred years ago William Barton Rogers, later to become founder and first president of the Institute, was writing a memorable letter at the University of Virginia where he was professor of geology at the time. The letter, dated March 13, 1846, was written to his brother, Henry, in Boston, who was also a well-known geologist, and in it William Barton Rogers revealed that already his thoughts had turned to the Boston area as the place for him to work to set up a new technical school:

> . . . Ever since I have known something of the knowledge-seeking spirit, and the intellectual capabilities of the community in and around Boston, I have felt persuaded that of all places in the world it was the one most certain to derive the highest benefits from a Polytechnic Institution. The occupations and interests of the great mass of the people are immediately connected with the applications of physical science, and their quick intelligence has already impressed them with just ideas of the value of scientific teaching in their daily pursuits. . . .[1]

William Barton Rogers then proceeds to formulate at length "A Plan for a Polytechnic School in Boston"[2] in which is outlined essentially the scheme under which the M.I.T. is carried on today. He first conceives that "A school of practical science completely organized should . . . embrace full courses of instruction in all the principles of physical truth having direct relation to the art of constructing machinery, the application of motive

(*Continued on page 436*)

[1] *Life and Letters of William Barton Rogers*, edited by his wife (Boston and New York: Houghton, Mifflin and Company, 1896), I, p. 259.

[2] *Ibid.*, pp. 420–427.

WEAVER OF SPEECH This photograph shows the wiring of a switchboard. After the switchboard is made, there is the further job of fitting it into the telephone system. It takes thousands of man hours to install a switchboard for just 1000 new telephone lines.

"We're coming your way with switchboards"

It takes time to make them and a lot of time to put them in. But we're hustling right along with the job.

We've made a dent in the pile of orders where the principal shortage was a telephone instrument. Most of the longer waits are where switchboards and new telephone buildings are needed.

You can be sure of this: We're putting everything we have into the job of getting telephone service back to normal. And then making it better than ever.

BELL TELEPHONE SYSTEM

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power, manufactures, mechanical and chemical, the art of engraving with electrotype and photography, mineral exploration and mining, chemical analysis, engineering, locomotion and agriculture."

This would require two departments: ". . . one in which by courses of lectures, amply illustrated, a broad and solid foundation should be laid in general physics, including especially the mechanics of solids, liquids and airs, and the laws of heat, electricity, magnetism and light, and in the chemistry of the more important inorganic and organic principles." This department, Rogers figured would require two professors — an estimate which today seems ludicrous as to quantity and implying either superficiality or universal genius on the part of the instructors.

The other and practical department was to "embrace instruction in chemical manipulation and the analysis of chemical products, ores, metals and other materials used in the arts, as well as of soils and manures." Practical, elementary mathematics, instruction in modeling and drawing, and courses in architecture and engineering were also to be given by this department, which was to be handled by two instructors who were to be subordinate to the professors in the scientific department.

But Rogers himself envisioned great expansion, for he adds immediately that a scheme of this kind would "prove so signally successful as ultimately to require its expansion into a polytechnic college on the most ample scale, in which, along with all the subjects above referred to, would be embraced full courses in elementary mathematics and instruction, perhaps, in the French and German languages. . . . I doubt not that such a nucleus-school would, with the growth of this active and knowledge-seeking community, finally expand into a great institution comprehending the whole field of physical science and the arts with the auxiliary branches of the mathematics and modern languages. . . ." Popular lectures by well-known scientists, similar to those given by Faraday, Wheatstone, and others at the Royal Institute of London, were particularly stressed by Rogers in his plan, and the Institute has always adhered to this course.

One single sentence illustrates perhaps better than any other Rogers' underlying theory of what a technical school should be and accomplish. He says, "The true and only practicable object of a polytechnic school is, as I conceive, the teaching, not of the minute details and manipulations of the arts, which can be done only in the workshop, but the inculcation of those scientific principles which form the basis and explanation of them, and along with this a full and methodical review of all their leading processes and operations in connection with physical laws." Several pages devoted to eulogizing science and its application to industry, agriculture, and engineering construction sound a bit trite today, but one must recall that Rogers lived in the generation which

(Concluded on page 438)

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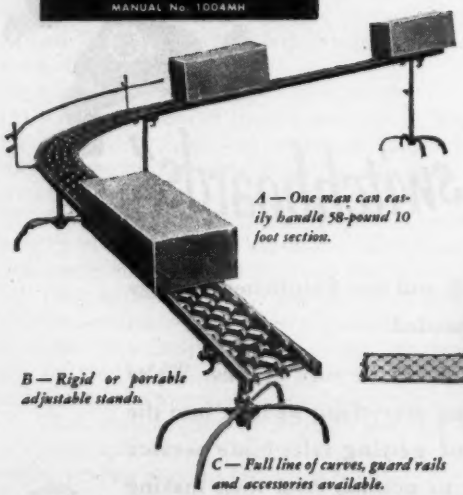

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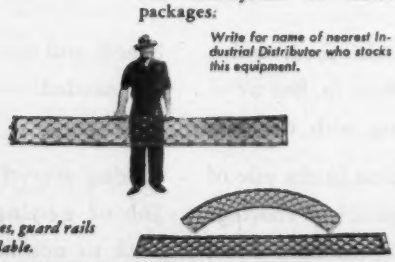

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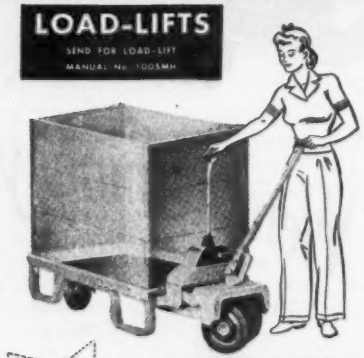

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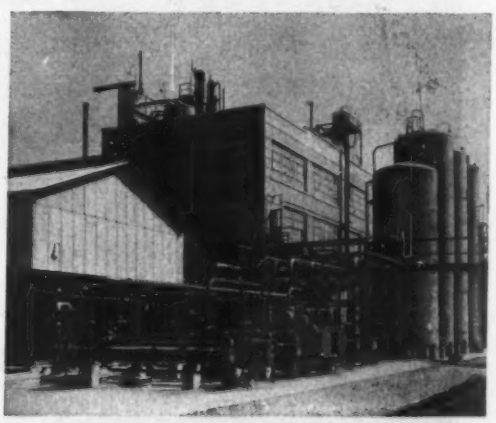

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THE INSTITUTE GAZETTE

(*Concluded from page 436*)

found revolutionary Herbert Spencer's *Essays on Education*, in which a comparison is made between classical and scientific education and the merits of scientific training are extolled.

Rogers neatly summarizes his plan in his final sentence by saying, "A polytechnic school, therefore, duly organized, has in view an object of the utmost practical value, and one which in such a community as that of Boston could not fail of being realized in the amplest degree."

The summer of 1846 found William Barton Rogers once again in Boston. Three years later he married a Boston girl, Miss Emma Savage, daughter of Hon. James Savage, LL.D., author of the *Genealogical Dictionary of New England*, and by 1853 he had left Virginia and settled in Boston. Throughout the succeeding years William Barton Rogers was to work increasingly to bring the technical institute into reality. Success crowned his efforts on the legal side when Governor Andrew on April 10, 1861, signed the Act of Incorporation of the M.I.T. only two days before the firing on Fort Sumter marked the beginning of the Civil War. It was almost 20 years from the time that William wrote his plan to Henry that classes began at the Institute; however, on February 20, 1865, President Rogers could write in his diary — "Organized the School. Fifteen students entered. May not this prove a memorable day!"

THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Continued from page 428*)

living but also of helping to formulate general educational policy. In fulfilling to the utmost his role as teacher, the scientist will be concerned with the relationship between subjects taught and the ultimate educational needs of his pupils.

How does the skill which the student acquires help him to solve the problems which seem most important to him in his subsequent life as a mature citizen? The problem of earning a living is, of course, one of the most important, but this problem is almost automatically taken care of by the very nature of our educational program and the organization of our faculties. We produce specialists whose detailed knowledge of medicine, electrical engineering, law, or some other aspect of human enterprise is likely to be sufficiently in demand so that they may expect to earn more than the average citizen.

It is clear, however, that while a citizen benefits from special advantages which he may have over his contemporaries, as in education, he may be limited by existing conditions in his community, in his country, and indeed in the whole world. He cannot live in health if his surroundings are full of disease. He cannot live in peace and happiness in a community permeated with social unrest and dissatisfaction or threatened from the outside with war. He cannot even effectively create dreams of a better life for which to strive if all his leisure moments

(*Continued on page 440*)

Prophet, *with* honor . . .

"Had a Jules Verne sought to imagine some universal servant of mankind, he would well have depicted some *magic agent* which would apply Nature's forces to do man's work . . . which could take the energy out of hidden coal and falling water, carry it by easy channels and cause it to give the light of a million candles, the power of a thousand men — or to produce heat without combustion, and unlock chemical bonds and release new materials . . ."

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But he himself built his own lasting monument to greatness — the giant industries he created. They serve today because they were founded by a man who looked ahead into the *future of human needs*, then found the practical means to satisfy them.

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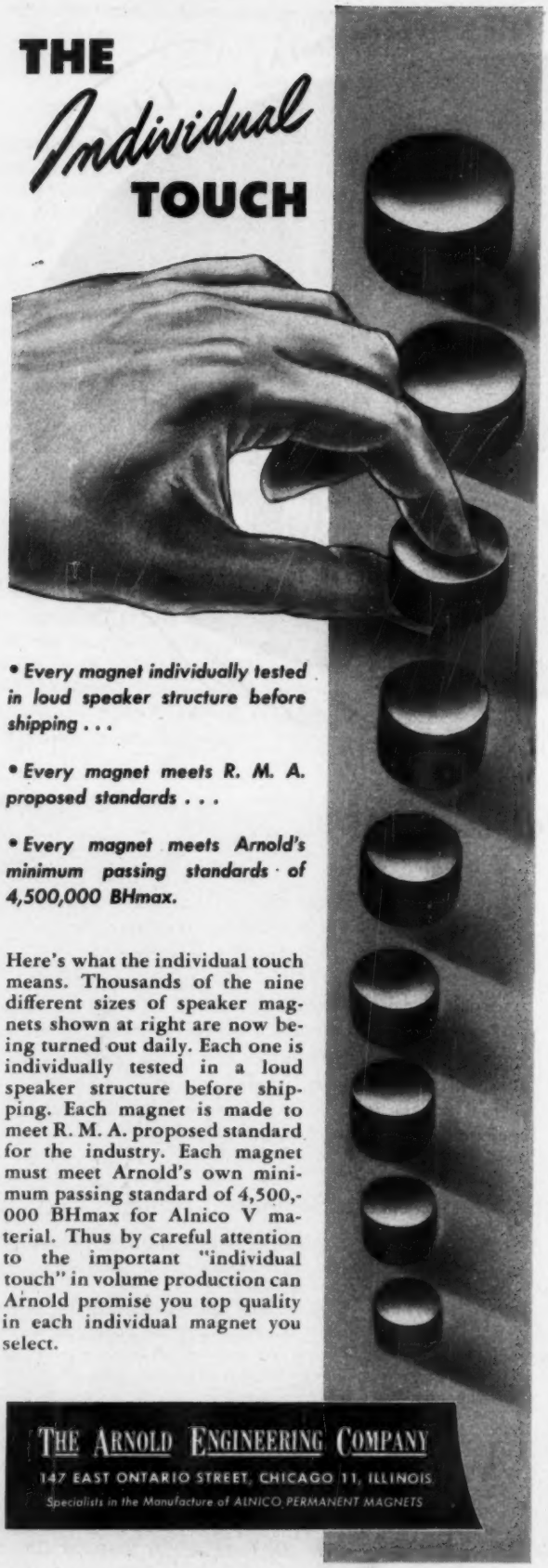

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THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Continued from page 438*)

are taken up with nagging worries which his physical and emotional surroundings force upon him. How, then, does the education of a student help him to cope with some of these more general problems which he has to face, either directly or indirectly?

The following partial list of subjects which a student is taught and of the nonprofessional problems that later concern him can readily be expanded by the reader:

What the student is taught	What the grown-up man is interested in
English	Health
History	Food
Geography	Clothing
Mathematics	Peace
Physics	Money
Economics	Communication and language
Chemistry	Transportation
Languages	Government
Philosophy	Energy
Biology	Entertainment

Clearly the average man is not taught specifically what he would like to know. Perhaps bits and pieces on the left will fit into the list on the right, but their interrelationships are certainly not as clear as one might wish.

There is no intention to imply that an attempt should be made to teach the student primarily how to apply knowledge to specific problems. Education is a tool, and its greatest value is perhaps its flexibility. It should be applicable to the solutions of yet unformulated problems, and the student should be made aware of the adaptability of knowledge first of all. But how can we expect the student to grasp fully and quickly the value of his education in connection with the problems listed if the instructors themselves do not bear this relationship constantly in mind? For example, in teaching the methods of science (*i.e.*, the collection of relevant data and their manipulation with the help of mathematics) are we not guilty of concealing its generality by emphasizing its applicability to physics, chemistry, and abstract geometry? How many students, when they leave a university, have any notion that simultaneous linear equations or the maximizing of an integral may be of practical value apart from standard engineering applications, or that the Bureau of the Census might provide data which could increase the value of these mathematical techniques?

The Task Ahead — And Mathematics

It seems clear that such broad questions require the close collaboration of specialists from many fields and that if the scientist is to make a contribution, he must study these new problems with the same devotion and thoroughness which have characterized his professional activities. The very selection of problems for solution requires a background of experience that can be acquired only by serious co-ordinated effort over a period of years. But it is precisely this kind of sustained effort that can eventually produce great results. Surely the problem of turning over to the next generation a summary of our

(*Continued on page 442*)

1 boiler to heat 10,000 homes?

Does the headline seem fantastic? It isn't — for, while it is not actually being done, there are boilers that could take on the assignment with ease. It's a matter of simple arithmetic. To heat comfortably an average-sized dwelling in mid-winter requires about 100 pounds of steam per hour, and Combustion Engineering is now installing at the Sherman Creek Station of the Consolidated Edison Company of New York the second C-E Boiler, in that station, to produce 1,000,000 pounds of steam per hour.

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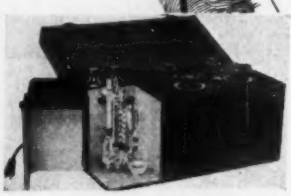

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THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Continued from page 440*)

experience and skill, in such a form that its relevance to the future is clearly demonstrated, is a task worthy of the collaboration of the best minds in all the fields of learning.

A scientist venturing into the new fields suggested here would probably feel that he could help in two ways: in selecting from past experience the data on which answers to present and future problems depend, and in selecting the mathematical tools required to produce a solution.

The significance of these two points to a scientist is probably not understood by most nonscientists. Perhaps most people can see that our ability to build trains, bridges, airplanes, radio sets, or atomic bombs is based on skill in selecting and manipulating data. Probably few realize that these things are merely incidental external manifestations of inner changes in the minds of men. Everyone is aware of the significance of an airplane for a man who wants to travel from New York to Tokyo. But how many realize the significance of various branches of mathematics to a man who wants to travel in the world of ideas, or the significance of painstakingly acquired data to a man who wants to travel from the world of ideas to the world of men and atoms? And how many of us really comprehend the fact that the great power we have discovered is not in the atom but in the mind of man and that it was not discovered in the last few years, but in the last few thousand years? Important though the future applications of nuclear energy may seem, our lives and those of our children will be even more fundamentally altered by the dissemination of mental skills, the true significance of which we are only beginning to appreciate.

Initial Steps

These generalities must be made more specific before we can consider possible modifications of our educational program. As has already been suggested, the collaboration of many specialists would be required to decide which branches of mathematics may be useful to the citizen of the future and to decide how far one can go in teaching the *use* of mathematics, apart from its structure, much as we drive a car with little knowledge of the mechanism under the hood. It is obviously beyond the scope of this article to consider this problem in detail. Although it is clear that increased mathematical skill is desirable, there is not much point in unduly emphasizing it in an already overcrowded curriculum when one considers that in most fields the basic quantitative data which might be subjected to mathematical treatment are missing.

But this vicious circle must somehow be broken. We must not continue to be satisfied with a situation in which essential data are not collected because those who might collect them do not understand their value for lack of suitable training — a situation in which, at the same time, people are not given this training because data for its application are missing. Obviously the first step is for those who have the required skills to consider problems outside their accustomed field and to direct the accumulation of the data which they may require.

A specific program for further development along these lines must necessarily be tentative and incomplete. It is

(*Continued on page 444*)

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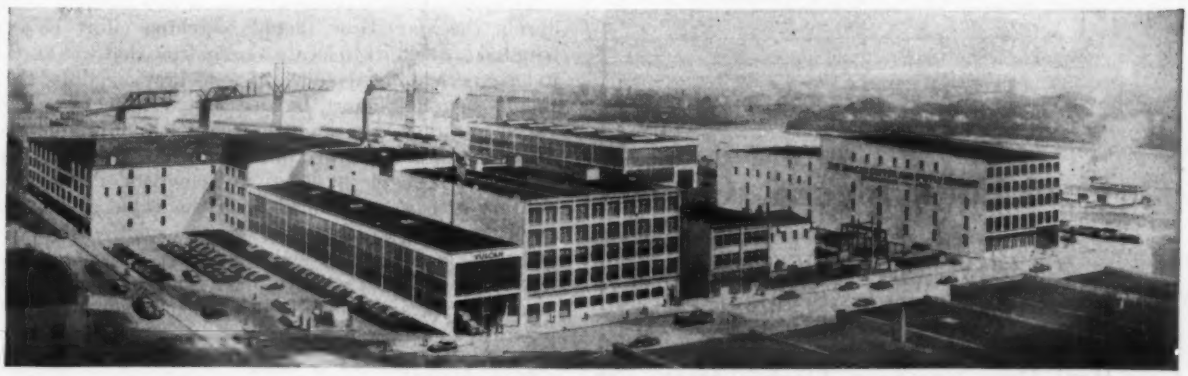

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THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Continued from page 442*)

always difficult to predict the results of research. Such experience as was gained in the analysis of military problems indicates that the first step, the selection of problems for study, is itself one of the most difficult problems. On the other hand, experience has also shown that valuable results may be obtained as unexpected incidental by-products of studies that fail of their primary aim.

A first step would surely be an attempt to formulate a series of problems of general interest involving more than simple arithmetic. If even a few people set about the formulation of such problems, the nature of these problems would be a valuable guide to further development of a research program. Here are three illustrations:

(1) The expected yield per acre is known for each part of a certain large tract of land, as well as the increase in the yield of each part due to the application of fertilizer in various quantities. How should a given quantity of fertilizer be distributed so as to maximize the crop?

Once stated in these terms, any mathematician would be able to solve this problem using the methods of the calculus of variations. But the formulation of the problem in these terms is probably beyond most farmers, and few mathematicians would think of bringing the solution, uninvited, to a farmer. Perhaps the problem is not well formulated from a practical point of view, but a discussion of the point might reveal other soluble problems that are of practical importance.

This same kind of problem arose in two different forms during the war. How should searching effort be distributed in an effort to locate a submarine that was known to have been at a given place at some previous time? How should bombing effort be distributed over targets of varying productivity to maximize the loss of production? These important military problems were formulated and solved, in principle at least, by scientists. Professional military men seemed unaware of the value of this formulation or the possibility of a general solution. The general solution is, of course, only a first step toward eventual maximum practical applicability, which can come only as a result of a continued interchange of ideas between practical and theoretical specialists, but once a beginning is made, there is at least the hope of eventual radical progress.

(2) Two gamblers have agreed to play a game until

(*Continued on page 446*)

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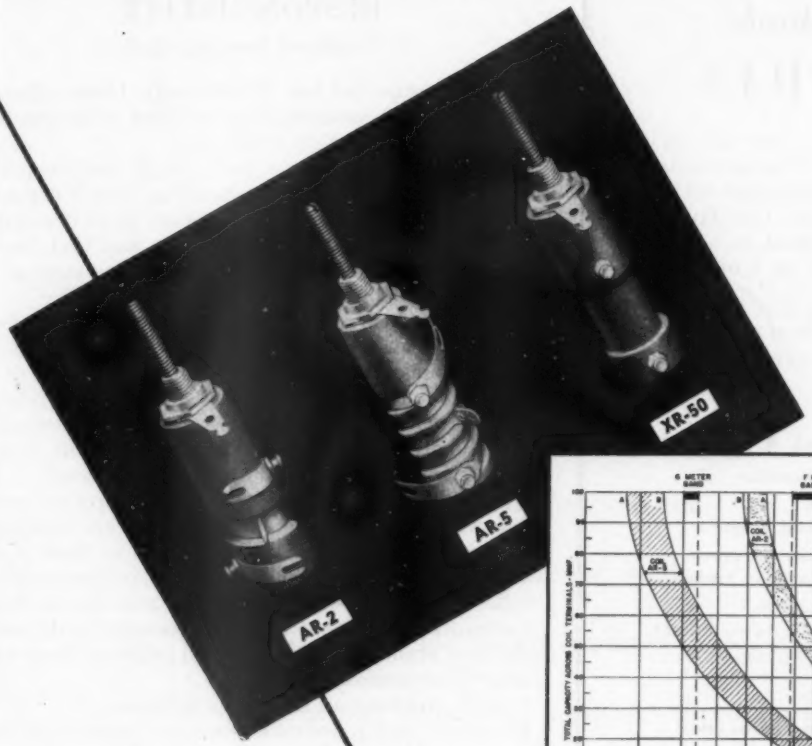

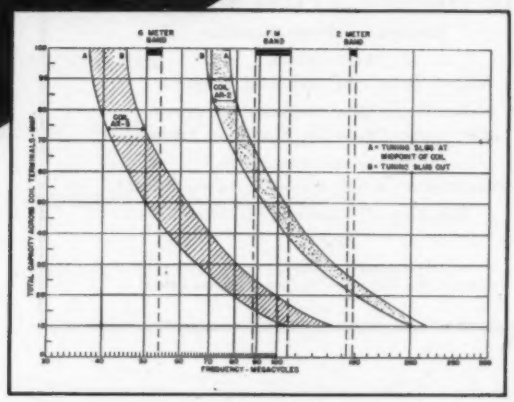

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THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Continued from page 444*)

one or the other has lost all his money. Under what circumstances is it advantageous for either of the gamblers to risk large rather than small sums?

It is interesting to note that a slight modification of this problem, in which the stake of the loser is destroyed rather than transferred to the winner, gives it a certain similarity to combat between armies, and that the answers to this modified problem are not the same as the answers to the original problem.

(3) An industrial system may be regarded as being made up of an arbitrary number of subdivisions, each of which supplies a fraction of its product to each of the other subdivisions. How can these interindustry relationships be formulated so that the altered requirements of each subdivision may be calculated, when the requirement for end-products is altered in a given way?

This problem, also, has its military aspect in connection with estimating the effects of strategic bombing or the conversion of an industrial system in time of war, but here again useful application depends upon continued collaboration between the practical and the theoretical specialists who can combine the necessary mathematical skill and available data with sound judgment in choosing simplifying approximations.

Such problems as these, the solutions of which are known or readily derivable, may be regarded as useful exercises that constantly keep before the student the generality of the methods involved. An attack on more complicated problems, the solutions of which cannot be given in a few lines and on which considerable research is required to obtain basic data, might also be attempted. In a preliminary effort to develop a useful body of knowledge, it would be desirable to choose several fields of interest and to formulate problems fairly generally, so that a wide range of specific subproblems might be revealed in the course of the investigation. Three more problems are listed below by way of illustration. Two of these are old problems and have been under the scrutiny of specialists for generations. The object of a review of available data and of conclusions already reached would be to discover whether a reformulation of certain aspects in more quantitative terms appears feasible.

(*Concluded on page 448*)

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THE SCIENTIST'S SOCIAL RESPONSIBILITY

(*Concluded from page 446*)

The first of these questions is in the field of public health. To what extent have people in various periods of history made use of the currently available knowledge of health and disease, and to what extent did accidental factors, such as the changing population of rats in our cities, play an equally important part in public health? A review of this subject from the point of view of the trained analyst should be of interest to every educated person, but particularly to scientists concerned with legislation affecting the control of new knowledge. What have been the typical blunders in the past, and how might they have been avoided?

A second example deals with a combination of economics and government. How has the productivity of economic systems varied from one period of history to another, and to what extent has productivity depended on the application of technical knowledge? In other words, to what extent have we profited materially from the results of research and invention?

A third and final example is taken from the field of national security. The war has amply demonstrated the vulnerability of cities to aerial attack, particularly with atomic bombs, and although there may be arguments about the military value of such attacks, there is no disputing their effectiveness in producing human suffering. Although we all hope that we and our children will escape future Hamburgs and Hiroshimas, this hope should not blind us to our vulnerability. This vulnerability can be decreased by dispersal. Here, then, is the question: What would be the national bill for the dispersal of our cities and industrial concentrations to the point where vulnerability to aerial attack would be materially reduced, and could this dispersal be designed in such a way as to provide incidental economic and social benefits which would give it the aspect of a desirable goal, rather than a mere flight from destruction? This problem, of course, is not one that could suitably be undertaken in all its complexity by a small research group at a university, but it is one that could be initiated under such circumstances, particularly with the object of developing methods of attack, of developing skill and imagination in quantitative planning.

This discussion illustrates possible first steps of scientists who feel that their discoveries and skills have put upon their shoulders at least a share of the responsibility for the intelligent application of new knowledge. What the results of such first steps would be, no one can foresee, but at least those participating in the work would benefit from a deeper understanding of the nature of the difficulties which their students will have to face during the years to come.

If there is any hope that men can live together constructively and in peace, this hope lies in men's ability to see clearly the nature of the problems confronting them and to bring to bear on the solution of these problems the full knowledge of the intellectual and physical means at their disposal. If the scientist, because of his training and experience, can help to educate men to this end, he must not fail — he must not be allowed to fail — in the fulfillment of this, his social responsibility.

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HIGH ROAD TO BROOKLYN

(*Continued from page 422*)

much longer spans than that at Brooklyn are to be as satisfactory. Without the benefit of present-day experience, they guessed well at the best ways to care for the resultant stresses and deflections.

Although Roebling and those of his generation may not have realized how much they were forced to guess in their design, they certainly built successful structures, which would be respected by today's engineers. As outstanding bridges of the time may be mentioned the Britannia Tubular Bridge, a pair of wrought-iron plate girders (23 to 30 feet deep), embracing two channel spans of about 460 feet and smaller adjacent side spans; the classic 580-foot suspension bridge of bar link cables at Menai Strait, Wales, then soon to celebrate its 50th anniversary; the ill-fated Tay Bridge, two miles long, then under construction; and, in America, the Roebling bridges previously mentioned and the famous Eads Bridge at St. Louis, then under construction.

The diagonal stays of the Bridge contribute to its rigidity. In computing the anchor chains Roebling blandly assumed that the stays took nearly one half of the vertical load of the Bridge, although possibly there is never a combination of temperature and relative elasticity of stays and cables that results in this assumed division of load between them. The use of diagonal stays was considered at the Tacoma Narrows Bridge in an attempt to restrain the vibrations that in 1940 caused its failure.

The cables of today's suspension bridges are fixed at the tower tops, causing the resultant differential of cable tension between side and center spans to be taken by the bending of the steel towers. Roebling had to make his towers of masonry, a material unsuitable for the stresses of bending. He had tried to balance cable tension of side and center spans by pendulum attachments in his Monongahela Bridge at Pittsburgh. It is readily apparent that such an arrangement was impracticable for the larger cables at Brooklyn. The rollers under the cradles at the Bridge towers have long since frozen in rust, and the Bridge is therefore three independent suspension spans.

One reason for the success of Roebling and his successors in designing a safe structure, despite the limited knowledge of the time, results from the conservatism of design and the generous assumptions of the live loads to be carried: eight tons for a one-horse truck, 30 tons for a two-horse one. "Two horses usually haul fourteen bales of cotton, four hogsheads of tobacco, or twenty-five barrels of flour or sugar. . . . One horse . . . sometimes . . . as many as forty barrels. . . ."

Overloaded as were the pitied horses of the quoted contemporary account, their burdens came nowhere near those assumed for the floor system of the Bridge. The basic concentrated load used for the George Washington Bridge was a 25-ton truck. As to the distribution of the basic live load, and the safe working stresses for various ratios of live to dead loads, modern structural designers are still in search of a truly rational method.

Not all designers of the period were as conservative as the designers of the Brooklyn Bridge. Frightful bridge disasters were too common as the newer steels came into use. "Not less than forty bridges fall in the United States every year," a report of the time states.

(*Concluded on page 452*)

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HIGH ROAD TO BROOKLYN

(*Concluded from page 450*)

Three years before its opening, New Yorkers who doubted the safety of the East River Bridge read in *Harper's Weekly* of the failure of the Tay Bridge in Scotland, in which scores perished. But Colonel Payne of the staff of their own Bridge engineers reassured them. Whereas "the Tay Bridge," he said, ". . . was not strong enough to resist the wind and wave pressures to which it was exposed," the strength of the East River Bridge was to be "five times as great as the force of a side wind against it."

(*To be concluded*)

INVESTING IN SCIENCE FOR THE FUTURE

(*Continued from page 426*)

unless such a group were willing to go further. It will be necessary to seek out and encourage promising young scientists and engineers who have projects which they might like to develop commercially. When such men are found, they will need associates who have considerable business experience and exceptional managerial skill.

To clarify what I have in mind here, we might look at the other side of the shield for a moment. Let us consider the Radiation Laboratory at the Massachusetts Institute of Technology. During the war, this university laboratory became one of the leading research centers in the world in the field of electronics. It specialized particularly in radar. The laboratory assembled an extremely able group of younger men from all parts of the country. A year ago, if you had interviewed many of these men, you would have found that a substantial number of them would have liked to start off for themselves. During the course of their war work they had uncovered a wide variety of new developments which had promising practical applications. When the war ended these men were suddenly deluged with offers from established industrial concerns to join their research staffs. As far as I know, there were no talent scouts ranging the laboratories at that time who were interested in getting new scientific enterprises launched.

Our educational institutions had, by and large, made no effort in their original training programs to encourage these men to start off for themselves or to suggest ways for so doing. Many of the younger men, nevertheless, had a nostalgic feeling that they would like to be starting something of their own; but when it came to a choice between a secure and clear-cut job that was offered to them and a much more hazardous and uncertain undertaking of forming an enterprise of their own, seeking capital, getting the proper business advice, and then going into business, they followed the line of least resistance.

I think that the situation is not incomparable to that which exists today in the publishing business. The modern publisher does not merely wait until a good book is planted on his desk. He thinks up ideas himself for books; he keeps in contact with the most promising young writers; he gives them fellowships and advances royalties; he nurses them along to a point where some of them ultimately become important producers. Of course, many of them never do, and, therefore, he has to diversify his risks by following this procedure with many different people.

(*Concluded on page 454*)

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INVESTING IN SCIENCE FOR THE FUTURE

(*Concluded from page 452*)

What type of new scientific ventures need support at the present time? A recently organized casting company is one illustration of the kind of venture that I have in mind. The "lost-wax" method of casting has been used for centuries, but it had never been possible to make castings of high-melting alloys. Scientists discovered a method of making ceramics which would stand very much higher temperatures. An ingenious engineer decided to start a small company which would make precision castings of all types, including in particular the castings of high-melting alloys. This field is by no means fully explored; it is unquestionably an expanding one.

A field which will undoubtedly have many further important developments is powdered metallurgy. The new scientific advances which have been taking place in this field could unquestionably be exploited by small new companies organized to develop certain specialized applications which have not previously been utilized.

Another type of venture which might be explored is the scientific application of developments in marine biology to certain well-known standard commercial products. It has been discovered, for example, that oysters can be economically and effectively grown on trays, and there are indications that somewhat similar techniques could be utilized in the growing of lobsters and other sea foods. If an enterprise were established to make commercial applications of the scientific advances that have taken place in marine biology, it might revolutionize existing methods.

The industrial application of the new technique of high-speed vacuum pumps affords another illustration. The National Research Corporation has been able to produce by vacuum distillation expensive organic materials, the valuable properties of which would have been destroyed if distilled at temperatures which would be necessary in the absence of high vacuum.

Still another recent illustration is the growing of vegetables in water or sand enriched with the necessary nutritive salt — the art which has come to be known as hydroponics. Developed first in California, it was used during the war for the production of vegetables on some Pacific islands where ordinary gardening was impossible.

I believe, in short, that there are many opportunities for the profitable employment of venture capital in financing new scientific enterprises; and I very much hope that investment groups will rise to this challenge and provide new methods and techniques of furnishing both capital and business help to the scientific entrepreneurs of the future. The burst of applied scientific development that has occurred during the war has demonstrated conclusively that we are not a mature and stagnant economy. Barriers to further progress lie only within ourselves. As the late President Roosevelt declared in 1944: "New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war, we can create a fuller and more fruitful employment and a fuller and more fruitful life."

One way in which these objectives can be achieved is to launch new enterprises of a scientific character. Every encouragement, therefore, should be given to promising young men with new ideas to start enterprises of their own. They need guidance, capital, managerial advice, and many other services. I believe that under the proper auspices the establishment of specialized investment companies to take care of this vital need would perform an extremely important function in the American economy today and help us to renew our faith in enterprise.

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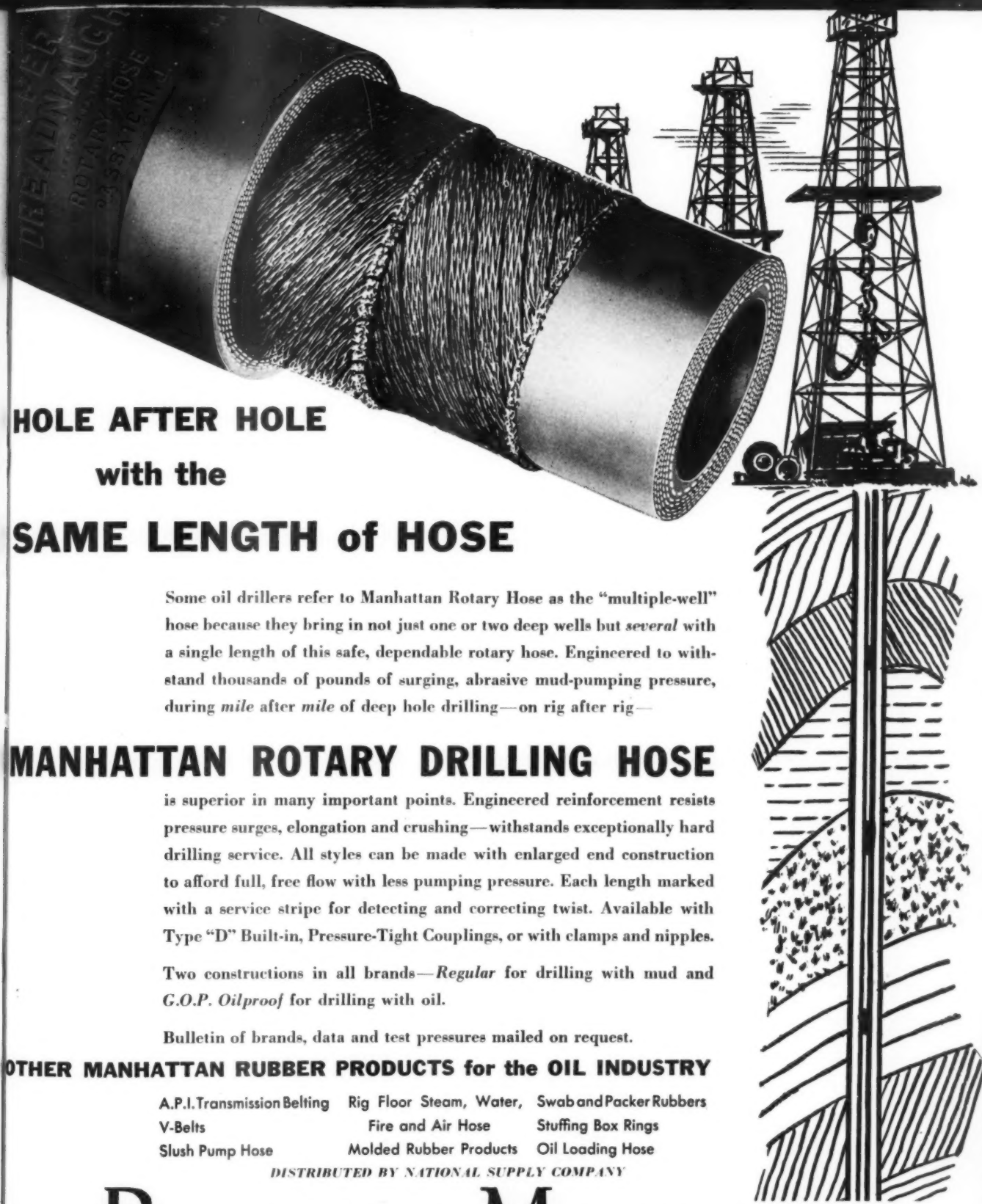

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SAME LENGTH of HOSE

Some oil drillers refer to Manhattan Rotary Hose as the "multiple-well" hose because they bring in not just one or two deep wells but *several* with a single length of this safe, dependable rotary hose. Engineered to withstand thousands of pounds of surging, abrasive mud-pumping pressure, during *mile* after *mile* of deep hole drilling—on rig after rig—

MANHATTAN ROTARY DRILLING HOSE

is superior in many important points. Engineered reinforcement resists pressure surges, elongation and crushing—withstands exceptionally hard drilling service. All styles can be made with enlarged end construction to afford full, free flow with less pumping pressure. Each length marked with a service stripe for detecting and correcting twist. Available with Type "D" Built-in, Pressure-Tight Couplings, or with clamps and nipples.

Two constructions in all brands—*Regular* for drilling with mud and *G.O.P. Oilproof* for drilling with oil.

Bulletin of brands, data and test pressures mailed on request.

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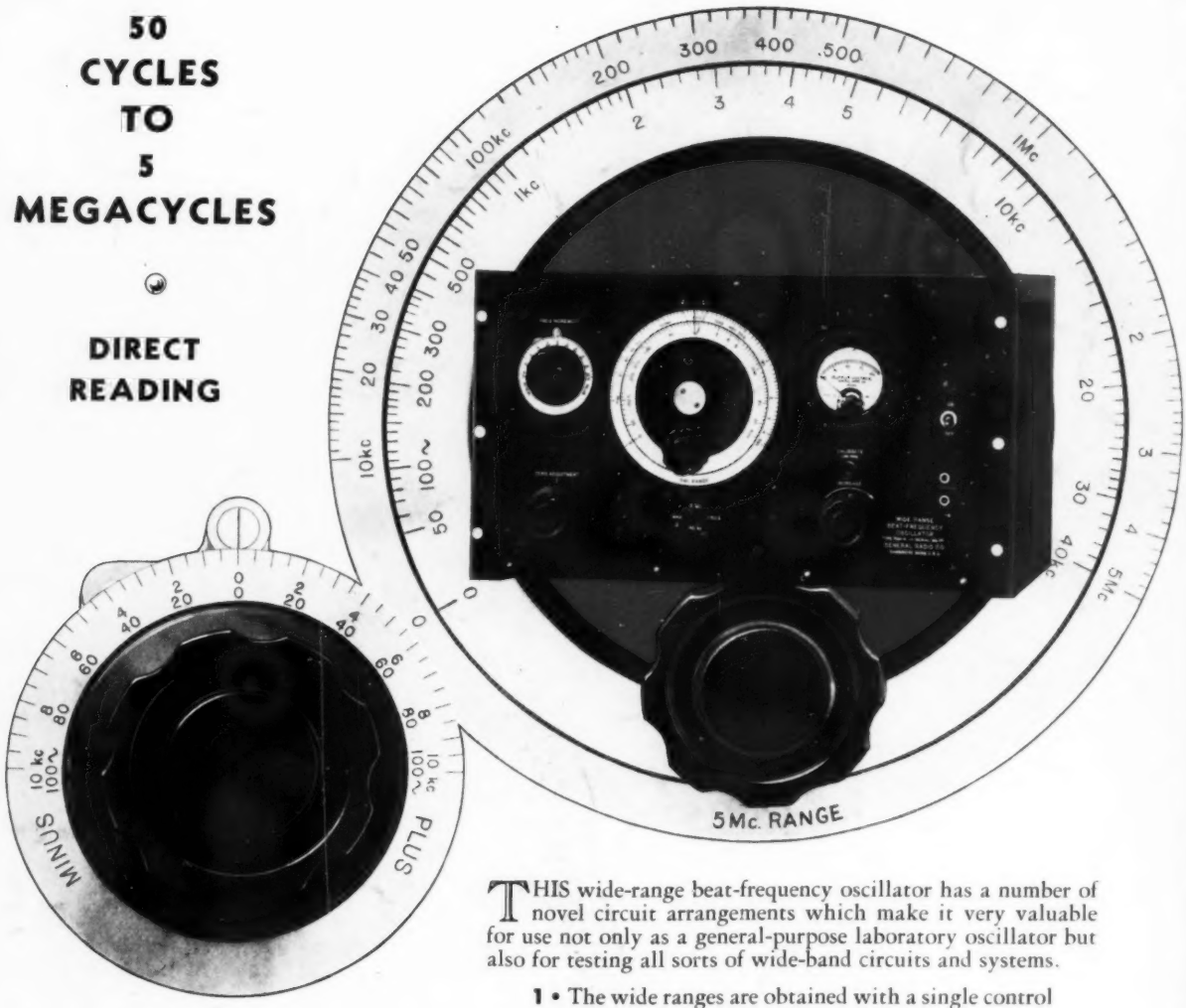
50 CYCLES TO 5 MEGACYCLES

DIRECT READING



FREQUENCY CONTROL AND CALIBRATION

The main dial is direct reading on two approximately logarithmic scales for 50 cycles to 40 kilocycles and 10 kilocycles to 5 megacycles. The incremental frequency control (above) is calibrated between −100 and +100 cycles and −10 and +10 kilocycles for the two respective ranges. Any frequency change made with this dial is added algebraically to the reading of the main dial.

The calibration may be standardized at any time, by setting the instrument to zero beat with the zero adjustment, to within 5 cycles on the low range and 500 cycles on the high range.

THIS wide-range beat-frequency oscillator has a number of novel circuit arrangements which make it very valuable for use not only as a general-purpose laboratory oscillator but also for testing all sorts of wide-band circuits and systems.

1 • The wide ranges are obtained with a single control knob and a two-position range selector switch
2 • The output voltage, by means of an a-v-c circuit, is held constant within ±1.5 decibels over the entire range
3 • Frequency drift is held to a very small value through carefully designed thermal distribution and ventilation systems
4 • Any small drift remaining may be eliminated by resetting the oscillator to zero beat
5 • A degenerative amplifier minimizes hum and distortion and also equalizes the frequency response
6 • The output voltage is measured by a vacuum-tube voltmeter across the output terminals
7 • One output terminal is grounded

For taking selectivity curves on tuned circuits over a wide range of frequencies this oscillator is especially useful in that these measurements may be made very rapidly and accurately through its use.

TYPE 700-A WIDE-RANGE BEAT-FREQUENCY OSCILLATOR.....**$650.00**

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